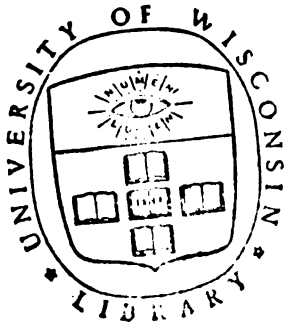

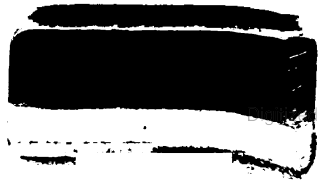

MEMORY AND THE LEARNING PROCESS

By

DARWIN OLIVER LYON

Late Fellow in Psychology, Columbia University

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TO

D. H. M.

IN MEMORY OF BAR HARBOR DAYS

CONTENTS.

PREFACE.*

The present work is the outgrowth of experiments on memory that I have been conducting since the year 1906. The first experiments performed were somewhat limited in character, being made solely with the view of ascertaining the relation existing between facility of learning and tenacity of impression. Whenever publishing brief abstracts of the work as it progressed, the title chosen as being the most appropriate was "The Relation of Quickness of Learning to Retentiveness." As the experimental work progressed, the method used became more elaborate, with the result that, though the relationship in question was never lost sight of, the data obtained were so extensive as to make the old title seem almost inappropriate. In a somewhat condensed form the results of these experiments, where they refer to the problem in question, are placed in Chapter IV. In a more complete form they constitute No. 34 of the Columbia University *Archives of Psychology,* Vol. V.

In 1908 experiments were started on *The Relation of Length of Material to Time Taken for Learning.* Two methods, or distributions of time were used and thus there was added an extra problem—a problem that we might call the *Optimum Distribution of Time.* The results of these experiments have been published in *The Journal of Educational Psychology,* Vol. V, Nos. 1, 2, and 3. In a slightly more condensed form they constitute Chapter III of the present volume.

The larger parts of Chapters III and IV are confined to the examination of data obtained by experiment, and can be of but little interest to any but the student in experimental psychology. Chapters I and II are also somewhat technical in character, so that, apart from Chapter V, this book can be of but little interest to the ordinary public.

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*This work was announced in 1914, shortly before the war, but its publication delayed until now because of the loss, in Germany, of the original manuscript.

Generally speaking, Education has use for Psychology only in so far as the latter may be of assistance in laying down rules for study. Education demands of Psychology that it show us how our various mental activities may best be developed, how to recognize and use our dominant form of imagery, what form of imagery to select under certain conditions and depending upon the object in view, how good habits of study may best be acquired, and how labor-saving devices—in so far as the mind is concerned—may best be disclosed and developed.

We do not presume to say that this book is an answer to such questions as these. Psychology is as yet unable to formulate definite rules on problems so complex. We merely pretend to discuss the learning process from an educational point of view, and trust, at the same time, that the conclusions we have drawn from the various experimental data may be of some practical use to the teacher.

Acknowledgments are due to Professors Cattell, Woodworth, and Meumann for the numerous suggestions given me in the treatment of the results.

Many of the experiments were performed on pathological subjects for purposes of comparison with the normal. In this connection I gratefully acknowledge thanks to the following for permissions and privileges granted:—Joseph F. Scott, Superintendent of New York State Reformatories and Prisons; Hon. John J. Barry, Commissioner of Correction of the City of New York; Dr. C. Macfie Campbell of Bloomingdale Hospital, White Plains; Dr. Frederick L. Wells of McLean Hospital, Waverley, Mass.; Dr. August Hoch, Director of the Psychiatric Institute on Wards Island.

INTRODUCTION.

The ever-increasing appearance of popular articles on topics supposedly relegated to the psychologist testifies probably more than anything else to the general interest taken in psychological matters wherever it is thought that any practical advantage may result therefrom. This is especially true of MEMORY, and the interest with which the layman reads articles on this subject is but proof of the fact that it is still felt some royal road to knowledge may still be found—some mysterious method by which a thing once heard shall be forever remembered. It might be supposed that in the field of memory—a field so admirably open to experimental research—the psychologist would hold full sway, but that this is far from being the case is evidenced by the large following that the authors of the numerous memory "systems" have been able to acquire from a public that ought to know better. The success that these men have gained is, however, not alone due to the practical advantages that their students hoped may follow the adoption of their master's rules, but also to the fact that the experimental psychologist himself has thus far been unable to lay down rules that, to an impatient public, seem of any great importance. It is possible that this inability of the psychologist to here give any positive aid is due to the relatively small amount of experimental work that has been done on such problems as memory-improvement, economy in learning, mnemonic systems, etc., but the reason more probably lies in the hard fact that—as will be explained later—memory, as a faculty of the mind, is unimprovable.

Though within the past decade the progress that has been made in Experimental Psychology has completely changed the general aspect of this science, and although an unprecedented amount of attention has been devoted to an experimental study of the various educational problems, relatively little has been done with memory, notwithstanding its great importance to psychology, pedagogy, and education in gen-

eral. Many psychologists have devoted the best part of their life to problems less important, but with the exception of Ebbinghaus, Meumann, and perhaps half a dozen others, no one has devoted himself for any lengthy period to the exclusive study of retention, recollection, and kindred problems. This is the more surprising when we consider its great importance. What can the psychologist tell us that is more important than how best to remember? The experimental study of memory for logical trains of thought has received but little attention, while an experimental study of the various systems of mnemonics seems to have received practically no attention at all. No experimental psychologist has as yet told us the most economical method of memorizing a passage of prose—or what method will give the greatest retention. Hosts of articles are found on other aspects of the memory problem, but as yet no one seems to have made these problems the subject of serious research.

Probably the main reason that there has been but little advancement in this field is due to the difficulties encountered when one undertakes to investigate this so-called "faculty" of memory. The reasons for this are twofold—that is, not only do the difficulties exist as a matter of fact, but they are increased by the erroneous conceptions held concerning this mental function. Memory is not a separate and distinct faculty of the mind, as is generally considered to be the case, but a gross, unanalyzable term, having no claim to represent an elementary function of mental life. Having been taught to consider memory as a natural, specific, and distinct property of the mind by which it acts uniformly and machine-like in a specific way, experimenters naturally supposed they could investigate it in much the same way as they could reaction time, sensation, rhythm, etc. This view is still the prevalent one, even among the more educated classes, and the average layman still looks upon memory as an elementary, separate, and distinct function of mental life. The error is an enormous one. To see this it is necessary to get rid of the wrong connotations that the word "memory" has acquired, and to use instead the term intellect. Memory properly interpreted is co-extensive with intellect, and in one sense of the word is part

and parcel of it. In reality—and as we shall endeavor to explain in the next chapter—there are many *kinds* of memories —as many kinds as there are senses and combinations of senses. To the sense of sight an orange is a spherical yellowish body, but this is, generally speaking, one of its least important qualities. Sight alone gives but a poor idea of an orange. We have a better conception of one when we remember its taste, its odor, its consistency, how it sounds when we cut it, how it feels when we handle it, and whether it grows on a tree or in the ground. All these impressions, and many others, are necessary for a full and distinct conception of what an orange really is, and, generally speaking, therefore, we may say that the more complete our knowledge of an orange, the more perfect will be our memory image.

In like manner with all conceptions. Take, for example, the law that the distance traversed by a freely falling body during any number of seconds is equal to 16.08 feet multiplied by the square of the number of seconds. Strictly speaking, to remember it we must know it; and to know it we must understand it. Now, for a complete understanding there must exist in the mind conceptions of time, space, and matter, conceptions of what "distance traversed" and "freely falling" really mean; and there must exist a conception of what the square of a number means. In short, everything that is involved in this phenomenon or "law" must have its internal representative in the mind. Why do we go so into detail on this matter? Merely because, as we shall later endeavor to show, MEMORY is based on imagery, and IMAGERY, to a certain extent, on our "conception of."

In much the same way as it is difficult to express the degree of perfection of an individual's imagery, so it is difficult to express the degree of his retentive capacity. We might even go so far as to say that it is impossible to say if a certain individual has or has not a "good memory." Too many factors are involved. One may have a very good auditory memory, but a poor visual one, or *vice versa*. He may, for example, stand high in the various memory tests as given in the psychological laboratory and yet find it exceedingly difficult to recall the names of people after introduction. It frequently

happens in performing memory tests on a class of students that he who stands first, and who, according to the tests, has the "best memory," stands low in his class and is considered by his teachers as "stupid" and of "poor memory." The fact of the matter is that the "memory tests" ordinarily employed in the psychological laboratories are narrow in the extreme and "test" but a narrow portion of this so-called "faculty." The retentive capacity is far from being the only factor worthy of consideration in school life. Interest, volition, power and rapidity of association, quickness of perception, acuteness of the senses—these and many others must be taken into consideration.

We are much too accustomed to look upon memory as a unit, and think of it merely as a faculty of the mind that permits us to retain and reproduce the various impressions (sensations and ideas) received. But psychology, psychiatry, physiology, and anatomy have shown us that such a conception is both too broad and too loose. The memory is an *ensemble* of operations of which each one has its proper sphere. These possess an independence to such an extent that any one of them may be strengthened—or weakened, and even disappear completely—*without causing the slightest change in the others.*

Another factor that greatly complicates the determination of any certain individual's retentive capacity is the problem as to what extent we should consider his faculty for learning mechanical habits. It is certain that the process by which we memorize a "logical," "meaningful," or "connected" train of thought is far different from that employed in the "learning" of a mechanical habit, e. g., typewriting, or telegraphy—and it is probable that the process, both from a psychological as well as a physiological point of view, is also somewhat different from that employed in the memorizing of a set of digits or nonsense syllables. The complexity of the problem may be seen when we consider such experiments as those performed by Bair[1] on the typewriter—where the keys were covered with different colors—and the writing performed by

[1]Bair. Psychol. Rev., Monograph Suppl. No. XIX. 1902.

watching a "copy" on which certain colors corresponded to certain letters. After the appropriate associations had been formed and "memorized" the colors on the keys were interchanged, so that a different reaction was called for to each of the former "color stimuli." In a case of this sort it is difficult to say just how far the "memory," as we ordinarily use the term, enters. It would be interesting to determine the correlation between efficiency for work of this type and that of memorizing prose.

Interest is one of the main factors to be considered in memory; it is the "mother of attention," and attention is the "mother of memory." Many a boy who can remember the winning team in the baseball games for five years back, with the names of the various players, the umpire included, may stand at the foot of his class in school. "Many a woman of a generally feeble memory can remember every dress she has owned since she was ten years old." [2]

In connection with *interest* we should mention *general understanding* and *intelligence.* Other things being equal, the more a man knows concerning a certain subject, the better will be his memory for facts connected with that subject. Thus, for example, the physician remembers a diagnosis; the merchant, prices; the minister, sermons, and the lawyer, verdicts. With this in mind the remarkable memory of certain scientists and philosophers is more easily understood. In his autobiography Herbert Spencer says he could never understand how it was that an ordinary card player could remember the various hands dealt at whist. Yet he himself remembered each and every fact that in any way related to his theory of evolution. Here the various facts he read or heard that in any way tended to verify his theory "clung" to him as grapes to their stem, and each addition did but seemingly make his memory stronger.

As before said, there can be no such thing as a general improvement of the memory as a unitary faculty. Our desultory memories are given to us once for all. We have not a faculty of memory that helps us as much for one subject as

[2] E. L. THORNDIKE. *The Elements of Psychology.* Page 259.

another, but a "faculty," if we must use the word, that is of unequal efficiency for different subjects. "No amount of culture," says James, "would seem capable of modifying a man's general retentiveness." Wherever a seeming increase in the power of memorizing has been obtained it is generally due to an improvement in one's method of work, for every individual has a certain scheme of remembering according to his habitual occupation, and this *scheme* he may change or improve. The broadest statement possible on this matter is that given by Lloyd Morgan:[3] "Retentiveness," says he, "is in fact to a large extent a psycho-physiological datum; something given in the brain-structure and mental character of each individual; something which we can no more alter than we can alter the size of our heads, or, to take what is perhaps a closer analogy, of the size of our muscles. By careful use and training we may develop our muscles within the limits assigned to them by nature. So, too, by careful exercise we may perhaps develop our retentiveness within the limits assigned to it by nature."

Strange to say, however, there are few questions in psychology on which the layman is so willing to give an opinion as upon methods of improving the memory,—and right here we have as good an example as may be given for the entrance of experimental psychology on such questions. This science has already overthrown many of the layman's pet theories, and the further the experimental psychologist carries his work, the more doubtful he becomes concerning many of the generally-accepted beliefs. "There are current in psychology numerous well-appearing theories which, when looked into, are found not to rest on experimental observation, but on a few superficial statements of fact, eked out by a vast amount of logical construction. All such are properly subject to suspicion, and the more beautiful and self-consistent the logical construction, the more suspicious they are, because they are so much the less likely to owe their acceptance to agreement with fact. The experimental psychologist holds that we shall never know much about the mind until we take the trouble to find it

[3] Lloyd Morgan. *Introduction to Comparative Psychology.* Page 107.

out, and that the trouble will consist in controlling the conditions under which observations are made and in using sufficiently fine methods of "observation."[1] Only by a careful scientific investigation can we determine the validity of the current views held concerning the mind's action. The popular belief is that "mental fatigue" follows very quickly upon protracted "mental labor." It has even been suggested that this "mental fatigue" is nature's safeguard to protect the muscles. This belief probably had its origin in the fact so commonly observed that people as a rule soon grow tired of mental work. The results of experiments, however, would seem to show that there is no such thing as "mental fatigue," as the word is ordinarily used. Memory tests have been continued without a break for five solid hours, showing, not a steady decrease, but a steady improvement. Thus experimental research has destroyed many of these popular ideas, and in a few fields has this been more true than in that of memory. Take, for example, the rules laid down by "Prof. Loisette" in his "Psychological Memory; or, the Instantaneous Art of Never Forgetting," a memory system that some 20 years ago was in vogue throughout the United States. The brazen effrontery and insolent presumption of this "System" is the only psychological explanation of the success it attained.

Notwithstanding that psychologists have shown the folly of trusting one's mental culture to systems so artificial, these have continued to advertise and thrive. The ridiculous pretensions and absurd claims made by "Loisette" called forth numerous publications attempting to "expose" his system, but for the most part they were unefficacious. The only redeemable feature of the "Loisette" system was that by advocating the use of certain definite methods for the formation of relationships it taught its followers to pay careful attention to their associations and thus weave the facts they wished to remember with something already known.

The perception of relationship is the *desideratum*. Whatever cultivation of memory that tends to the arrest of the power of rational thinking is to be absolutely avoided. Apart

[1] R. S. Woodworth. *Psychiatry and Experimental Psychology.* Proceedings of the American Medico-Psychological Association, 1906. Page 128.

from mere names, numbers, and words in general, the mind in attempting to retain facts should seek inherent and essential relations, particularly those of *cause and effect,* reason for and *subordination* (individual—species). Generally speaking, therefore, we hold that the various memory "systems" and schemes of mnemonics so in vogue at present are to be condemned without reservation.

Experimental psychology has proven that the best way to remember a thing is to *know* it. The only improvement that can be made in the memory is to alter one's habitual methods of recording and recollecting. By this we mean that the most rational method of improving the memory is to seek to *know* and *understand* the things we wish to retain. Go about the matter in a logical way, think over the subject carefully, and classify and tabulate the various facts as they come to mind. Endeavor to file the various facts in an orderly arrangement, and make this habitual if possible. This is the method used by the scientist, and in the end it is the only method that is of any use for logical trains of thought.

Though, as already stated, it is probable that one's native capacity of retention is unchangeable, this does not mean that one may not improve one's methods of study. Experiments have been made that prove the superiority of the "whole" method as opposed to the "piecemeal" method;[5] that prove the superiority of short study periods as compared with long ones,[6] and that prove the superiority (in retentiveness) of "stringing out" the study periods instead of finishing the work in one sitting.[7]

Psychologists are now quite unanimous in saying that one's native retentiveness is unchangeable, and that no amount of training can modify it. It is a physiological quality, and as it is given us at birth, so it remains. It may fluctuate with health and change with age, but this is all that can be said of it. Education can alter it but slightly, if at all. To be born, therefore, with a high retentive capacity is one of the

[5] Lottie Steffens,—Zeitschrift. Vol. XXII. 1900. [For definition of these methods see Chapt. IV.]

[6] D. Starch. *Periods of Work in Learning.* Journal of Ed. Psych. Vol. III. Page 209.

[7] D. O. Lyon. Journal of Educational Psychology, Vol. V, Jan., 1914.

greatest of blessings, for retention is the *sine qua non* of human mental activity. It is probably the most important power of the mind so far as education and culture are concerned. Without it all advancement would be impossible, since it is only through the storing up of experiences, i. e., "memories," that mental progress is made possible. Other things being equal, the man with the best stock of ideas can reason the best. His life will be fuller and more complete, and he will be able to perceive relations and formulate laws impossible for the man whose native retentiveness is poor. One might even say that a fair degree of retentive power is necessary to a proper development of the emotions. Take, for example, the most typical of the altruistic emotions, sympathy. To be a good sympathizer one must have had experience; he must be a good observer; he must be a good thinker; he must possess a good imagination, and he must have a good memory. The last is really the basis of the other four. To be a good observer one must be on the alert to perceive the cause of grief. He must be able to detect pride, fear, shyness, and embarrassment, and to appreciate these he must be able to *recall* how *he* felt at times like these and the occurrences that caused them. The more vivid a person's imagination, the easier he can put himself in his friend's place. Now, as is well known, imagination must have at its basis a stock of ideas and images to start with, and this "stock" is part of *memory*. Taking everything into consideration, we think we are justified in saying that one of the greatest boons that can be granted a man is a high retentive capacity.

CHAPTER I.

ON THE FORMS OF MENTAL ACTIVITY INCLUDED UNDER "MEMORY."

The divisibility of memory.—Testimony of anatomy, physiology, and psychology. Aphasia. Training along any special line does not necessarily improve kindred actions.—Mental improvements not transferable. "External" and "internal" forms of memory activity. Memory in its relation to Association and Reasoning. "Literal" learning and "logical" learning.—The association of words v. the association of ideas. Types of Imagery or Forms of "Presentation":—visual, auditory, olfactory, gustatory, tactile, motor. Verbal memory. Professional and occupational memories. Effects of education, environment, sex, race, etc. There are as many ways of comprehending as there are forms of imagery. *Visual* imagery a form of "external sensitivity," *acoustic* and *motor* of "internal sensitivity." Importance of the subject to Pedagogy.

An *idea* (in the sense of *complete mental image*) of an object is both more complex and more variable than we usually imagine—complex because images of the various senses enter into its make-up, variable because no two images of an object are ever the same, but vary with the time, place, and circumstances. The *image* that arises when we shut our eyes and endeavor to recall a person or object depends, as we shall later explain, upon the individual's type or form of imagery—this, in turn, depending upon his sex, race, education, environment, age, etc.

It is the same with words, spoken or heard.[8] The word heard may recall not only a souvenir of the sensations felt when pronounced, but a souvenir of the movements made when writing it, as well as a visual image of the word, written or printed. The question is one of interest not alone to the psychologist, but to the physiologist and anatomist as well. For if it be that there exist in the cerebrum certain *areas* or *fields* corresponding to the various senses, it must follow that when one of these "areas" is cut out or its functioning suppressed, peculiar or irregular phenomena will occur. To the

[8]Here again neither is simple, but either form recalls, to a greater or less extent, the other.

physician and physiologist such phenomena are well known and are frequently brought about experimentally. It is possible by a certain operation on the cerebrum of a dog to so isolate the optic area that, although it in itself may function, all "association" with other "areas" is prevented. Such a dog is psychically blind. He *sees,* but no longer comprehends what he sees. Through accident or disease similar conditions may occur in man, and the physician encounters them frequently in the various forms of aphasia. SENSORY APHASIA appears clinically in three distinct forms: (1) simple loss of memory for words; (2) *word-deafness,* or inability to understand spoken words; (3) *word-blindness,* or inability to understand written or printed words. Various forms of MOTOR APHASIA also exist. In the so-called *motor* or *atoxic* aphasia there is a loss of speech owing to an inability to execute the various movements of the mouth necessary to speech. The patient cannot be said to have forgotten the word, for he can write it, but he is unable to pronounce it, notwithstanding that there is no paralysis whatsoever of the mouth or tongue muscles. The cause of all this is a lesion in a certain part of Broca's convolution, though to the ordinary observer the patient appears merely to have forgotten how to pronounce the word. There are other forms of motor aphasia—these depending on the site of the lesion. In *agraphia* there is an inability to express thoughts in writing. In *alexia* there is inability to express written language in words.

We have gone somewhat more into detail on aphasia and kindred matters than may seem necessary in a book of this sort. It is our object, however, in this chapter to show that the memory is not a single, separate, and distinct "faculty" of the mind, but a gross, unanalizable term having no claim to represent the functioning of any one portion of the brain. The various aphasias and kindred phenomena brought about experimentally on animals that our so-called "*memory*" is composed of a great number of primary memories, which are distinct one from the other and which may be lost separately.

In like manner with the improvement of any of these various memories. If the brain functioned as a whole, we might assume that training along any special line would improve all

kindred or allied actions, but we know that such improvement does not take place. Were it that the brain functioned in sections or compartments corresponding to "memory," "judgment," "discrimination" or other of the so-called "faculties" or "phrenological organs" we might expect that the training of any special performance within the scope of a faculty would benefit alike all other performances included within that faculty. "But since the evidence points to a highly detailed localization of cerebral functions, and since the neural mechanism employed in any performance cannot be wholly identical with that required for slightly different performances, though it may be partly the same, training in one performance would not be expected to improve another, except in so far as the neural mechanisms involved were in part identical, i. e., employed the same cells, fibers, and synapses. As applied to psychology, this would mean that, in order for a transference of skill to occur from one performance to another, there should be between the two, not simply likeness in the abstract, but some concrete part-performance in common, as there is between fighting and boxing, or between saying 'boot' or 'book.' In general, since the neural process in any reaction undoubtedly has more detail than appears either to introspection or to objective observation, it will not always be possible to point out the common features of two reactions; but that there should be features in common if any transference of training is possible from one to the other seems necessary from the physiological point of view."[9]

Working with simple mental tests—such, for example, as the cancellation of 3's and 5's in a list of mixed digits, Poffenberger* sums up his conclusions on this subject as follows:

"(1) Where there are no identical bonds between stimulus and response in the two processes, the influence of one process upon another will be zero, i. e., there will be neither transfer nor interference. (2) Where there are identical elements in the two processes, or where a given process involves one or more bonds previously formed, there will be a positive trans-

[9] Ladd & Woodworth. *Elements of Physiological Psychology.* Page 566.

*"The Influence of Improvement in One Simple Mental Process Upon Other Related Processes." *Psch. Bull.*, 1915, Vol. XII, page 65.

fer effect. (3) Where one test necessitates the breaking of previously-formed bonds and the formation of new ones there will be a negative effect or an interference."

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When by introspection we examine our stream of thought or analyze our various sensations and sense impressions we discover that there are *various forms of mental activity* included in that which we are accustomed to call memory. There is hardly an activity of the mind that is not in some way related to it or that does not come more or less under its head. It matters not if it be the learning of a poem or a rule in grammar, the latest song or the face of a new acquaintance, how to solve a puzzle or play a new game—each and all smack of "memory," and it is only because they possess certain factors in common that we can group them under this head. It behooves us, therefore, to make clear these various forms of memory activity before discussing memory in the narrower sense of the word. This done, we shall then discuss the process by which we learn, the various forms and types of memory, and the various forms of imagery—with an attempt at classification.

For the present we may roughly divide all memory activities into two classes—(1) those of "external" origin, and in which one or more of the so-called "senses" comes directly into play; (2) those of "inner" origin, and in which association and reasoning form a prominent part.

1. Memory activities of "external" nature, or, roughly speaking, observation.—Here we include the activity of the senses, and, generally speaking, all sense perceptions. This form of memory activity is witnessed when, by observation, we have "impressed" upon us the objects presented to the senses. The impressions are mostly visual, but any sense perception may enter. As already stated, this form of mental activity generally passes under the name "observation," and comes especially into consideration where *space* is entailed, as, for example, in the study of a geometrical figure; or with *time,* as in the learning of a melody.

2. Memory activities of "internal" nature or origin.—These are more difficult of definition. We here include the processes of association and reasoning. Memorizing by association is what we ordinarily term "learning" or "learning by heart," and consists largely of an *association of words.* The really active factor in this form of memory activity is not the mere perception of the senses (single or repeated), but the repetition and reiteration of the various ideas, images and associations between them. The process is largely one of *fixation of impressions,* and takes place in all true memorizing, especially in the verbal form known as "learning by heart." When, for example, we are committing to memory a passage of prose or poetry, each word and phrase that we perceive (be it by eye or ear) signifies something to us, and it is these "significations"—with the associations formed—that give the mind material to work on.

Another form of memory activity that we must classify under this head is that which takes place when we wish to get the significance (meaning) of an article, conversation, lecture or description without learning it word for word. This process calls in the reasoning faculty, so that here *association of ideas* comes more into play than association of words. The perception (be it visual or auditory) of the separate words plays a much smaller part here than in the "learning by heart" just spoken of. Nearly all that the average adult learns is acquired in this manner. While reading the average man does not pay any particular attention to the individual words, their order or number. He endeavors merely to get the significance of the various sentences and paragraphs and associate their meaning with facts he already knows, impressions he has already received, emotions he has already felt, etc. The *idea* (meaning) is what is retained—not the words—though these may be reproduced because of vivid visual images, or by sheer accident. Thus it is that an educated man can retain in one reading what might take an ignorant man or a child many readings. The extraordinary performances of the logical memory in men of science is easily explainable when we consider that, while reading a book or listening to a lecture, all such minor details as the meaning of each and

every word, the construction of the sentences, arrangement of words, etc., are easily put aside and the memory reserved for the nucleus of the argument. Another reason is that, though a true repetition or re-reading of the lecture may not take place, the result is much the same as though there were, for the scientist has so large a stock of ideas on his particular subject and is so continually occupied with them—reflecting, correcting, refreshing, etc.—that he may be said to be *continually reviewing his material.*

Between learning (memorizing) by the association of words and learning by the association of ideas there is considerable difference. For purposes of discussion we shall term the former *literal learning;* the latter, *logical learning.* Literal learning calls into play one or more of the senses. Imagery of some form is invariably a factor. Logical learning, on the other hand, does not necessarily employ the senses; when it does, the employment is seldom direct, but secondary, in the form of imagery. The attentive faculty is more of a factor with literal learning than with logical learning, and is employed in a more direct manner.

We frequently hear a difference of opinion concerning the memory power of a certain individual—one speaks of him as having "an extremely good memory"; another, as a man of "relatively poor retentive capacity." Upon examination this difference of opinion will generally be found to be due to the fact that where the one refers to his "literal" memory, the other refers to his "logical." We can all cite cases of men whose powers of literal learning are remarkable, but whose "logical" memory is weak, and cases of an opposite character are equally common. It should not for a moment be imagined that these two forms of memory are separate and distinct—the one sharply marked off from the other. On the contrary, each, to a certain extent, depends on the other. Association is a factor in both; in "literal" learning, however, it is more of a *motor-auditory* type, whereas with "logical" learning *reason* and *logical associations* predominate. Memory, in the sense of native ability to retain impressions, sounds, words, etc., or "brute" memory, as it is sometimes called, is admittedly stronger in children than adults. The logical memory,

on the other hand, is weaker. This latter is due not merely to the fact that the adult has a larger stock of ideas and can therefore reason better, but because the attentive faculty is stronger in adults than in children.

Generally speaking, we may say that facts memorized by literal learning do not "last" for so long a period as those memorized by logical learning. The speed of light, cause of the tides, distances of the planets, etc., are quickly forgotten by the student who uses his "literal" memory—based largely on motor or auditory images. The astronomer, using his logical memory, never forgets them. This difference in length of retention is due to several things, but mainly to the fact that the *intention* or *object of memorizing* is different in the two cases. The same astronomer who uses his logical memory on the matters cited above would probably use his literal memory were he to attempt to recall a set of nonsense syllables just read to him, or were he to desire to retain in his mind a question asked him while he sought the answer. For in both of these cases there is no *desire* or *intention* on the part of the individual to retain the matter memorized for any length of time. In one sense of the word literal memorizing is a continual *refreshing* of the primary impression—a continual revival or restoring to life of something once partly or wholly memorized. Thus it is that the work is so much more *intensive* and demands greater *concentration* than logical memorizing.

TYPES OF IMAGERY, METHODS OF LEARNING, AND FORMS OF PRESENTATION.

Anyone who has performed memory experiments on a considerable number of individuals, such, for example, as the presenting of a passage of prose to a class of students with directions to learn it by heart, is struck by the great individual differences—differences in method of study, time of learning, degree of application, amount retained, fidelity of retention, duration of retention, etc. All these are open to experimental investigation, and have already been dealt with to a greater or less extent by the experimental psychologist. To him all such problems are of interest, even though certain

of them are of relatively little educational value. To the pedagogue and educational psychologist the problem of chief importance is the relation of the *time taken for learning* to *amount retained,* or, to be more specific:

1. The relation of time taken for learning to *amount* directly retained.[10]

2. The relation of time taken for learning to *duration* (permanence of retention) of the material retained.[11]

3. The relation of either of these to the *method* used in the memorizing.[12]

No. 1 has been investigated by Ebbinghaus, Meumann, and others. The matter is somewhat without the scope of this work, though we shall touch upon the subject later on. No. 2 has as yet received but little attention from the experimental psychologist. In a work devoted wholly to this subject the author discusses it in detail under the title "The Relation of Quickness of Learning to Retentiveness."[13] The problems that fall under No. 3 are considered in the present treatise, chiefly in Chapter IV.

In investigating any of these problems it will be found that they fall into two grand divisions—(1) the slow learners, (2) the quick learners. With each of these two subdivisions are again necessary—(a) the good retainers, (b) the poor retainers. Other things being equal, just why one individual should have better native retentiveness than another is not easy of answer. The problem, however, of why he is able to memorize more quickly—to learn more quickly—than another individual is more susceptible of experimental investigation. Many factors, however, must be considered, e. g., method of study, material used, rhythm, attention, association, mnemonics, etc.

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[10]This is not a question entailing individual differences. The matter is exactly as stated—i.e., What is the relation between *time* and *amount*?—e.g., If it takes 5 minutes to learn 20 words, how long will it take to learn 40?

[11]By this we mean the relation of quickness of learning to retentiveness—i.e., Do those who learn the quickest remember the longest?

[12]The question here is twofold—(1.) What *method* of memorizing is the shortest—i.e., what method gives the greatest amount [of material directly retained]. (2.) What method gives the longest duration [time].

[13]D. O. Lyon. *Archives of Psychology,* (Columbia University). Vol. V, No. 34.

In order to discuss intelligently the various types of learners (*Lerntypen*) it is necessary we first consider the types of imagery (Vorstellungstypen), or, rather, to be more specific, the various methods of learning depending upon the method of imagery or mental "presentation." It is the custom of the present-day psychology to divide and classify memory into several classes or types, these depending upon the dominant sense or dominant form of imagery employed in the mental process in question. On an anatomical-physiological basis such a classification might be expressed somewhat as follows:

1. Visual.
2. Auditory.
3. Olfactory.
4. Gustatory.
5. Tactile.
6. Motor.

It will be observed that the first five correspond to the classical "five senses." The sixth corresponds to what we might term the muscular, kinetic or kinesthetic sense. In the strict sense of the word, there is no such sense, motor imagery being more or less a combination. It is not to be understood that to classify one's imagery is a simple matter, that each and every individual can be thrown at ease into one of the above divisions, and that these divisions are clear-cut and distinct. On the contrary, it is frequently a difficult matter to say just what one's predominate form of imagery is. When we speak of an individual as being of the "auditory type" we mean that in the *ensemble* of memories retained by this man auditory imagery is either *predominant* or more *clear* and *alive* than in the average individual. In a considerable number of people two or more of these forms of imagery may be so high and so nearly equal that they may be said to predominate at the same time. In fact, this is usually the case with our great sculptors, artists, and musicians—our virtuosos. Excellence in but one form of imagery, be it ever so high, is seldom[14] sufficient to make one a master among

[14]Exceptions occur only in such cases as those of some "lightning calculators," chess-players, etc.—where a certain form of imagery—usually visual—may be greatly in excess of all others.

men. To be great a sculptor must have not only his visual memory developed to an extraordinary degree, but his motor (kinesthenic) as well; without it he will lack *execution.*

That which characterizes a person's type of memory—that makes him, for example, of the *visual* type rather than the *auditory*—is that he has the habit of *preferring* visual imagery in his various mental operations. It does not follow that such an individual has no auditory imagery as though he lived in a world of sight. For the nature of one's imagery varies with the time and the circumstances—or, to be more exact, *according to the sense with which he is paying attention.* Thus it is that a person of the visual type may, if he desires, evoke auditory images—auditory images that are perfectly clear and intense, and that differ in no way from those of the average individual.

It must not be imagined for a moment that there are six, and only six, forms, or types of memory. Various groups and combinations of these types exist, to say nothing of the various subdivisions of each type. For example, there exist at least three forms of visual memory:

1. *Color*—and brightness.
2. *Shape*—and size.
3. *Place*—and movement.

Some authorities hold that only the first form is truly visual, the two others being called the false visuals, because in these it is not the retina with its associated cortical centers that plays the principal part, but the various muscles of the eye which (by their various contractions and relaxations) permit us to form an idea of the object's shape, size, and place.

As a matter of fact, there are many more than three subdivisions of visual memory, and the three forms given above are but general in the extreme. We now know that one can push further the above classification and detail subdivisions to each of the three forms. With No. 1, color—for example, we may speak of shades, hues, depths, etc.; effects and degrees of light and shadow; colors that with some individuals give a sensation of sound or of smell, and others that cause the pulse to quicken or give rise to certain emotions. The visual

imagery in such a case is obviously more complex than in the normal individual.

To go into a detailed discussion of the remaining types and sub-types of memory and imagery would be outside the scope of such a book as this. The six forms we have mentioned are sufficient for our present purposes. The classification made is a physiological one, and the six forms are thus more or less *ideal.*

The chapter would be incomplete, however, and certain of the experiments later to be described not well understood, were we not to devote a few words to a form of memory which, for want of a better term, we shall call the VERBAL MEMORY. Psychologically, the chief thing that differentiates man from the lower animals is his ability to express himself in words. A natural concomitant of this ability to express his thoughts by words (*language*) is that of *thinking and reasoning in words.* The larger part of the memory images as recalled by an adult are in the form of *words,* and we may say that the development of memory is always more or less concomitant with the development of language. The constant employment of verbal imagery in the mental operations of civilized man has become so habitual and so firmly rooted that we may all now be said to possess what we may call an *inner language*—a language that accompanies (or rather is part and parcel of) our various acts, judgments and feelings. These at the time of their occurrence are felt and expressed in words to such a degree that the image retained is more or less a verbal one. Thus it is that we may be said to store away and carry about with us a large part of our various experiences done up in "verbal packages," so to speak. Thus it is that when we revive an experience or sensation we do not reproduce the sensation itself (though this may occur) but only a *story* of it—a story in words. Introspection will prove to anyone that whenever he attempts to reason, especially if in a careful and methodical manner, a voice within him arises that *formulates his reasoning in words.* It matters not what the mental action may be—be it the observation of an object, a decision, a judgment or a sensation—in each and every case

verbal imagery enters in. It has been experimentally proven that every time one hears a word or sound the mouth, and especially the tip of the tongue, make a movement—a "sketch-like" movement, as though there were a desire to reproduce it. It is a frequent occurrence to hear one who attempts to recall a certain word say, "I can almost remember it, for I have it on the end of my tongue." There are people who do a large part of their thinking in a loud voice, and who appear to *talk with themselves* whenever they think. Their "inner" language becomes "outer," and they say aloud that which the ordinary individual *says to himself.* We may feel—experience a sensation—without words, but as soon as one dwells on the sensation and attempts to reason about it, state its cause or give its effects, *words arise.* Theoretically, it is possible to feel a sensation, experience an emotion, see an object, or even take a decision *by sensation alone* and without the employment of verbal imagery; but the latter nearly always enters in more or less. An examination of this verbal image reveals the fact that in its most habitual form it consists of a mental repetition of a word once pronounced—an auditory image of a word or group of words. It may be simple or complex, sharp cut or ill-defined, lasting or evanescent—but it is always there.

Each and every word, provided that it is understood, carries with it a great number of reminiscences, so that in a certain sense we may look upon every word as a compacted memory.

Verbal imagery cannot be called a native form of imagery, it being both a derivative and combination of other forms. It has arisen only in the process of man's mental evolution, and is highest where culture and civilization are highest. In children and the anthropoid apes it occurs only in a low and most undeveolped form, and can truly be said to exist only where verbal language exists. As to its origin, we might say that it is probably based on motor and auditory imagery, visual imagery surplanting the latter in individuals of the visual type.

Space does not permit a detailed discussion of the remaining forms of imagery.[15] Those that we have considered are, for a work on memory, those of chief importance. TACTILE IMAGERY is undoubtedly the most primordial of all, and is a dominant factor in the mental life of all animals. In man the organs of feeling by which tactile imagery is formed may be said to reside chiefly in the fingers, lips, and tip of tongue.

OLFACTORY IMAGERY. This form of imagery is used in our thinking more often than we are apt to imagine, and in some individuals is developed to an extremely high degree. In the case of the French novelist, Zola, it was developed to such an extraordinary extent that we are justified in calling him an individual of the *olfactory type*. For Zola, every object had its proper and characteristic odor. It was the same for every person, city, street, or what not;—provided he knew them intimately enough, each one had its proper odor. His olfactory memory extended even to the times and seasons. "L'automne, par exemple, lui paraît caractéristique avec son oduer de champignons et de fueilles nouillées."[16]

GUSTATORY IMAGERY. But few people have this form of imagery sufficiently intense and developed to such a degree as to entitle our calling them of the gustatory type.[17] Gustatory

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[15]As imagery is based upon the senses, it behooves us to emphasize the fact that these latter are by no means limited to the "classical five." Besides the peripherally-initiated feelings of external origin (such as the auditory, visual, etc.), we have the peripherally-initiated feelings of *internal* origin (pain, muscular effort, hunger, nausea, etc.) Besides all these we have the emotions or centrally-initiated feelings.

[16]TOULOUSE. *Emile Zola une enquête medico-psychologique.* Paris; 1896. Page 206.

[17]I know of but one case so developed as to warrant the term. This gentleman (J. R. H.) employs gustatory imagery to a large extent in his various mental operations. This is especially noticable in his recollections of people and places—which are frequently connected in his mind with some article of diet. For example, recalling some of his old friends, he said, "Yes, Phyfe always had good roast-beef, and Mr. Wing fine lima beans; Gordon had good roast-potatoes, and Mrs. Goff fine cod-fish cakes and corn-bread." In like manner, speaking of milk at the hotels, he once said, "The Ritz in London has very good milk; the Ritz in New York is good, but not quite so good; Delmonicos has poor milk. The best glass of milk I even drank was up in the country at———s. The Murray Hill Hotel has good ice-water, omlets, and Welsh-rarebits; they have not changed their Welsh-rarebits or roast-beef in the last thirty years. I remember that the last time I dined there [six months ago] the bread was not so good as usual." His gustatory memory goes back to boy-hood, "I remember," said he, "when a little boy, of a certain dish of

images are seldom pure, and usually include a greater or smaller amount of olfactory imagery,—due undoubtedly to the close connection that exists between the two senses. As to its relation to tactile imagery, we have only to remember that the taste of an article depends partly upon how it *feels* to the tongue. The terminal filaments of certain branches of the nerves of taste have been found to end in the area of general sensibility, situated in the parietal lobe.

Besides the six primary forms of memory, with their various subdivisions, there are various combinations and complex forms that are difficult of classification. We have already spoken of the memory of ideas and concepts, showing its relation to the verbal memory; but what shall we say for the memory of feelings and emotional states? And how, apart from being able to say that auditory or visual imagery may enter in, shall we classify the memory of meaning of abstract terms? We have tried, but we have been unable to form a satisfactory classification. One of the best and simplest might be stated as follows:

1. Memory of the *six senses,* including motor memory. (Here also are included memory for *space,* and, to a certain extent, that for *time.*)
2. Memory of the emotion and states of feeling.
3. Memory for ideas and concepts (such memory being based on memory for names and abstract word meanings).

Neither the memory of space (extent) or of time (duration) have received from the experimental psychologist the attention they deserve. Cattell and Fullerton[18] in an extensive study of memory for lifted weights found that the memory image would appear to last for a period of about nine seconds, "after which the observer does not so much compare the sensations as decide on the approximate intensity of each sensation separately and compare the decisions."

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roast-potatoes I eat at———. *I can taste them now.* I remember that Barbara Dunigan made the best currant-pie and cooked the best dish of string-beans."

He has proven to me that he is able to reproduce a real gustatory image—vivid and well defined. The subject is an extremely well educated man. Apart from the gustatory part, an examination of his memory shows nothing remarkable. To learn the 20 words (v. p. 172) took him 13 minutes.

The results and conclusions drawn from the various experiments that have been performed along these lines do not always agree. Jastrow[19] in working on memory for space found that neither the visual nor the tactful variety suffered as much with the passage of time as we might expect. Both forms appeared almost as faultless after a lapse of several days as after a few minutes. Other experimenters, however, notably Landau[20] and Weber[21], found a more or less regular decrease.

As to the memory for *time* intervals, here also there is some difference of opinion. Paneth[22] found that the memory image (for time) was as sharp and clear-cut after an interval of five minutes as after an interval of but one. Hollingworth[23], from a larger and more carefully-planned set of experiments, concludes that "the curve of memory for duration follows more closely the ordinary statement of the 'law of forgetting,' in the case of the constant error, although the variable error undergoes little change up to an interval of 30 seconds."

The various "types" of memory that we have considered in the preceding pages may be considered as *native* or anatomical-physiological. Each of them is to a greater or less extent influenced by education and environment. We thus have types of memory corresponding to the various professions and trades—types that we may designate as the physician's memory, mechanic's memory, chemist's memory, etc. The nature and direction of the *attention* is, in all such cases of course, an important factor, and this is especially noticeable in the case of certain special trades and professions. Take, for example, the professional chess player, waiter, or actor. Here in each case the memory is developed along the special line desired by the individual in question. Here the degree of development will, of course, depend partly on *the will*, the *attention* being habitually directed in one special direction.

[19] Cattell and Fullerton, "Small Differences," p. 147.
[19] Jastrow, *Mind*, Vol. XI, 1902, p. 552.
[20] Landau, *Wissensch. Rev.*, 1896.
[21] *Wagner's Handwörterbuch der Physiologie*, p. 2.
[22] Paneth, *Centralbl. für Physiologie*, Vol. IV, 1890, p. 82.
[23] Hollingworth, "The Inaccuracy of Movement." *Archives of Psychology*, June, 1909, p. 86.

Take, for example, the professional chess player; he has, as he plays, a certain number of memory images clear-cut and sharply defined. To these alone he pays attention, to the exclusion of all others. Long practice makes this habitual and almost automatic. The process is but an example of the law of the conservation of energy. There is no fatigue, and all unnecessary action is eliminated.

Where, however, education and environment show their greatest effect is in the case of sex. In all countries the environment with which the boy is surrounded is so different from that of the girl, and the education received by the one is so different from that received by the other, that we are justified in distinguishing a *masculine memory* and a *feminine memory*. Apart from reasons biological it is but natural to suppose that the masculine mentality differs from the feminine. Women *think* in a different manner from men; their *psychology* is different; their interests are seldom the same, and their attention seldom centered on the same object. We usually give women credit as having a livelier imagination and stronger emotions, and it is well known that these things have their influence on memory.

The effect of education and environment is also observed in the memory-differences seen in the various races. The psychology of the Indian is quite different from that of the European, and the mental imagery of the Mohammedan is not the same as that of the Englishman.

We could push the argument further, but the effects of education and environment on imagery and memory as witnessed in *profession*, *sex*, and *race* are sufficient. Suffice it to say that, generally speaking, *there are as many types of memory as there are individuals who retain.*

The method by which one learns depends upon his method of presentation—his type of imagery, his way of thinking. It will be noticed that we differentiate between *learning-types*[24] and *types of imagery*.[25] An individual of the visual type will,

[24] In German.—*Lernmethoden.*

[25] In German.—*Vorstellungstypen, Sinestypen, Gedächtnistypen, Anschauungstypen,* or *Sprachtypen.*

when given a set of digits, memorize them by visual imagery; but he may learn to memorize them in auditory manner if so directed. It frequently happens that one's profession or walk in life necessitates the employment of some other form of imagery than his dominant one; for example, that a bank clerk of the visual type remembers numbers and words as read to him. In such cases the continued practice and exercise of the weaker or dormant form of imagery results invariably in a great increase of its power. Pedagogically, such questions are of considerable importance. To what extent, for example, should a man endeavor to choose his calling and select his business in the line of his dominant form of imagery? And to what extent should he endeavor to improve his other forms? To what extent does a man's habitual or strongest form of imagery influence his life and affect his relationship with his fellow-beings? As yet we do not possess very definite answers to these questions.

We do, however, know that along any special line or direction the faculty of *attention* is capable of unlimited improvement, i. e., the rapidity with which we may *adapt* ourselves, and the intensity with which we may *concentrate*. We also know that the attempt on the part of an individual to develop his lesser or dormant types of imagery results very frequently in a lessening in the power or vividness of his dominant type—the type to which he seemed to be born. A phenomenon of a similar nature is seen when we attempt to educate "lightning calculators" of the type of Fuller, Buxton or Colburn. In the case of Colburn a repose of three months (during which period he discontinued his representations before the public) resulted in a very considerable loss of his powers. Experiments have proven that the acoustically born individual suffers a temporary diminution in his acoustic memory when by exercise he attempts to increase his powers of visual imagery.

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The way in which one comprehends depends upon his form of imagery at the time. Individuals differ widely as to their types of imagery and combinations of these types, with the result that there are many *ways of comprehending* and *methods of learning*. When reading a book the *visualist* "fixes"

a considerable number of his impressions as written or printed images. He makes mental (visual) note of the words and groups of words, notes their arrangement on the page and remembers on which *side* of the page occur statements or sentences of particular interest or beauty. In short, the matter is one largely of visual imagery.

The *acoustic* or *motor* type of individual, on the other hand, sets himself to put the material that he reads *into the form of heard or spoken words.* Unlike the visualist, he does not perceive the *ensemble* in any *one* instant, but one word must follow after the other. This brings us to the main difference, or point of distinction, between these two forms of imagery. Visual imagery entails the factor *space* in its make-up, whereas acoustic and motor imagery entail *time;* and thus it is that visual imagery is, as it were, a form of *external sensitivity,* whereas acoustic and motor are forms of *internal sensitivity.* Unlike the visualist, the acoustic and motor types are not able to have, during reproduction, the various words or objects of a "series" before the "inner eye" at the same time. The visualist, on the other hand, "sees" the whole thing in a "glance."

Another advantage possessed by visual imagery is that as a whole it is both truer and more reliable than the auditory or motor type. Several observers[29] have proved this experimentally. Each type, however, has its advantages and disadvantages. True though it may be that the visualist is able to observe and "fix" his images more securely, he takes more *time* to do this than does the motor or acoustically inclined individual.

This subject of imagery is of capital importance to the pedagogue, for it is just with children that modifications in the method and manner of producing and reproducing images are most easily initiated. The plastic mind of the child is vastly more susceptible to changes in the form of imagery than is the adult mind, but unfortunately the average educator pays no attention to the fact. To the kindergarten

[29]Notably Pohlmann, Meumann, Munsterberg, Kirkpatrick, Whitehead and Finzi.

teacher also, the subject of imagery is of importance. It enters to a greater or less degree in all systems of education and training of the young, especially in such as those devised by Montifiori, Fröbel, and Pestalozzi. The results obtained with these systems coincide with the results we have obtained from experiments performed in the psychological laboratory, namely, that the present system of education entails a great loss of time. There is a great expenditure of time and energy, and relatively but little of value accomplished.

CHAPTER II.

THE SUB-DIVISIONS OF MEMORY IN GENERAL, WITH SPECIAL REFERENCE TO THEIR RELATIONS TO THE LEARNING PROCESS.

Sub-divisions of the memory process:—retention, reproduction, representation, identification.

Retention an essential feature of all life—conscious and unconscious. Retention is influenced by: (1) Condition of the organism, (2) Strength and clearness of the impression, and (3) Repetition.

Reproduction is the process by which objects that have previously been known are brought back into consciousness for representation and use *Imagination* v. *study*.

Identification the highest department and final stage of memory. Three factors to be observed: (1) It is a form of cognition, (2) That which is known is *re*-known. (3) It is of *my* past.

Methods of investigating the learning process: (1) Method of description, (2) Method of reproduction, (3) Method of identification, (4) Method of comparison.

Memory is usually defined as the mental capacity of retaining unconscious traces of conscious impressions or states, and of recalling these traces to consciousness. But this is not all. A further analysis of memory (if we use the word in its more general sense) will reveal the fact that the mind must be conscious that the impression, sensation or mental state in question has a certain relation to the past.

In the fullest and most complete sense of the word, a complete act of memory will be found to involve four processes: (1) retention, (2) reproduction, (3) representation, and (4) identification.

Retention may be defined as that capacity of the mind that keeps and stores up the various facts, sensations, images and ideas that may later be called on for reproduction. With retention pure and simple the mind is not conscious that any of these knowledges exist, for as soon as consciousness enters we have reproduction and recognition.

Reproduction is the process by which objects that have previously been known (be they mental images, states of feeling, or what not) are brought back into consciousness for representation and use.

Representation is that stage of memory process that consists in the mind presenting to itself the objects that have previously been known. It may or may not be accompanied by identification. When this accompanies it the process is finished, and we have a complete act of *memory*. When recognition does not accompany it we have *fantasy*—a form of representation in which the images brought before the mind are severed from their ordinary relations.

Identification is that stage of the memory process in which the object is *recognized* as having belonged to or been in connection with a past experience. It includes not only the element of *time*, but that of *self*. That is, not only are we assured that the object in question represents some knowledge or experience of the past, but that this past knowledge or experience was our own.

The above are but definitions. We shall now consider each of these sub-faculties in detail, and endeavor to explain just how we retain, how we reproduce, how we represent and how we identify.

Retention.

The act of retaining or the maintenance of changes caused by external stimuli is an essential feature of all life.* In fact, in the broadest sense possible it is a feature of inorganic things as well. It is an axiom that the quantity of movement existing in the universe is invariable and constant, so that when we see force being expended on a body it follows that changes of some kind in that body must follow. The body is *altered*—an alteration that exists at the expense of the change in motion. For wherever there is motion there is displacement. The displacement may be permanent or only temporary, affect the mass as a whole or only parts of it, but it is always there.

*In much the same way that we define retention as the maintenance of changes caused by external stimuli, so we may speak of memory in general. This is the view frequently held by biologists, some of whom go so far as to say that memory is nothing but an *acquired character*. The trouble with such a definition, however, is that it includes *instincts*, which, resulting as they do from habitual modes of action accidently acquired, have been preserved and transmitted by natural selection and heredity.

When a current of electricity passes through a wire the wire is altered. This change, however (unless the current be very strong), is but temporary, though theoretically it is doubtful if the wire ever returns to exactly the same condition as before. Similar phenomena may be observed with other forms of force. When we send a stone through the air or throw it into a pool of water, the fluid medium (in the one case air, in the other water) is agitated and set into motion. The material is, however, altered, but for a relatively short time, and though certain molecules are displaced and their places taken by others, the fluid may be said to return to its original condition.

In other cases, however, we may witness a permanent change—this depending upon the nature of the material and the nature of the force affecting it. The current of electricity may be *so* strong as to cause a change of shape in the wire, or the water, if frozen, *so* non-elastic that the portions separated by the blow of the stone cannot return to their former position. In short, as shown by Herbert Spencer, the matter is also a physical one, and depends not alone on the nature and amount of the stimulus, but also on the solidity and elasticity of the body affected.

We are now in a position where we may better understand the psychical process of retention—a phenomenon of a sufficiently similar nature as to be comparable to such physical phenomena as those cited above. In the psychical act of retention there must be a molecular or atomic change of some sort in the brain substance, although the exact *nature* of this change is unknown. We are still ignorant of just what takes place in the brain when we reason. We are unable to differentiate, in terms of change in brain structure, an emotion of love from one of hate, or a sensation from a judgment. We only know that during the process in question movements of some kind must exist, and that these leave their traces in the form of a more or less lasting change in the nervous tissue.

The comparison may be carried further. It is a matter of everyday observation that the object or body that has once had a certain change wrought on it by an external force or stimulus can be made to adopt this new form with a lesser ex-

penditure of energy every successive time. The overcoming of resistance is a phenomenon of habituation. It is easier to fold a piece of tin if it has already once been folded, and where the water has made a channel there it flows most easily. *Habit* is not only a mental affair—something confined to the cerebrum. Any organ may show its effects. Liver, stomach, and intestines may become habituated as well as the brain. One may contract a strange manner of walking as easily as a strange manner of thinking, and the muscles are as easily deformed as the mind.

Retention is influenced by several things. For purposes of discussion we shall group these under three heads:

(1) Condition of the organism.
(2) Strength and clearness of the impression.
(3) Repetition.

Condition of the organism. The results of operations performed on animals and man, certain psychoses, and the various diseases of memory as witnessed by the specialist in nervous diseases, prove that the faculty of conservation is intimately connected with the cerebral organism. The effects of cerebral disorganization are best studied in the various forms of amnesias, but to a lesser extent we may also observe them in old age, fatigue, and the action of such drugs as alcohol, opium and cannabis indica.

Strength and clearness of the impression. Six subfactors are to be noted:

(a) *Strength of stimulus.* Generally speaking, the stronger an impression, the greater its chance of remaining in consciousness. It is a matter of everyday observation that feeble impressions are soon forgotten.

(b) *Clearness of stimulus.* A stimulus may be strong, but not clear, or vice versa. By clearness of stimulus we mean distinction of ideas, i. e., to what degree is the image or idea clear-cut, sharply defined and separate from similar images and ideas.

Good retention necessitates complete understanding, and ideas that are vague and confused are not well understood,

and hence not well remembered. It is obvious that *attention* is an important factor in this connection.

(c) *Organization of ideas.* Generally speaking, it is only by organization and classifying our various knowledges that they are remembered for any length of time. This is especially true of the pure sciences in which perfection can only be retained by constant classification, the formation of systems, and the rational ordering of new ideas as they enter. Analysis and synthesis, deduction and induction are all processes to be considered under this head.

(d) *Independency.* Facts that we have worked out for ourselves or that we have learned through experience, are relatively well retained. What we invent ourselves, be it in the form of an idea or in the construction of a machine, is not easily forgotten. In short, it is a question of origin, i. e., does the knowledge in question come from within or from without? It is obvious that attention and interest have to be considered under this heading.

(e) *Attention.* The influence of attention on the retentive capacity is too well known to need any discussion.

(f) *Emotion.* Ideas and images that are formed during periods of great emotional activity are practically never forgotten. A lively or *vif* emotion is retained forever.

7 **Repetition.** This subfactor is of such importance that it may replace all other conditions. The effects of routine and habit are too well known to require any discussion.

Reproduction and Representation.

We shall discuss these together for the reason that they are very closely linked, and the one practically necessitates the other. The memory does not merely conserve ideas—it also *reproduces* them and makes them again "alive."

Reproduction, as we have already said, is the process by which objects that have previously been known are brought back into consciousness for representation and use.

The reproduction of an idea or image may be passive and arrive spontaneously, or by the active process of association. In the former case the image arises without our being able to

give the reason, as, for example, when in the middle of a piece of work a certain melody forces itself into consciousness. Generally, however, the reproduced idea or image arises by association. This latter may be voluntary, or more or less involuntary. When, for example, we behold a certain house we may recall our childhood days—children with whom we played and the recurrence of certain events, and a continuation of such recall may go on for some time undisturbed. But it is always in such cases under the control of the will, and may be stopped any moment.

The process may be more or less automatic. If the element of volition enters but slightly, we call it *imagination.* When, however, the voluntary element predominates, we call it *study,* as in this case the endeavor to learn and acquire is brought about by means of mental application. At such times there is a process of effort and exertion, and we "endeavor" and "try" to get one idea or image to recall another.

During our waking hours the various impressions and sensations that we receive from the world around us, especially if our attention is centered on them, direct our stream of thought and keeping out as they do, extraneous or unallied matter, exercise a sort of repression. In imagination the stream of thought is more or less allowed free play, and there is but slight repression. In sleep and reverie, however, the stream of thought is let run as it will, and though one idea may follow another through the activity of the process of association, this process is not directed by the will—as is the case in study.

In recalling a mental state, be it an idea, sensation, or what not, there is a passage of a current that affects the cerebrum in a manner more or less similar to the way it was affected the first time the mental state occurred. As to how far the two processes are identical will be discussed later. Suffice it for the moment to say that it is not probable that the brain tracts excited in the recall are perfectly identical with those excited by the event at the time of its original occurrence.

The reproduction and representation of an image may be caused in various ways. As a rule, it arises because of a visual or auditory stimulus. I happened just now to recall St. Marco's Cathedral in Venice. I recalled it for the simple

reason that I happened to lift my eyes and saw the photograph that I once took of it. But the recall might have taken place in many other ways, e. g., by a photograph of some other cathedral, by the name "St. Marco," or possibly by the mere word "cathedral." The degree of perfection of the image would naturally vary in the different cases. The most complete and perfect recollective image would be produced only by again beholding the Cathedral itself.

It is evident that this department of memory is more or less linked with, and may even consist of, *association*. The association may be one of ideas, sensations, images, emotions, or other form of mental activity, but in one form or another it is always there.

Some psychologists hold that there are two varieties of reproduction, depending upon whether the object is recalled from within or without, i. e., they distinguish between an image that is recalled by the individual himself (from within) and the image that is recalled by a stimulus from without. In short, they differentiate *remembering* from *being remembered of*. They hold in support of this classification that it is impossible to recall a series of mental images or representations without one of them having arisen and been caused by *external* stimulation. No reproduction, they claim, is otherwise possible. This school explains reproduction by holding that real bonds or connections (anatomical or physiological) exist between the members of a series, and that we are able to pass to another group or series only because of the fact that there exists an element in common between the two. Some go so far as to hold that the bond is *material*. The other school claims that the connecting bond in association is purely a mental one, intellectual and ideal.

Generally speaking, the rapidity with which a former idea or state of mind can be recalled depends both upon its degree of vividness and upon the frequency with which it has been recalled in the past. When for the first time we recall and restore before us a certain state of mind it does not "arise" with rapidity. In order to obtain it quickly it is necessary that it be a state of mind that has already frequently occurred

in the past. [Repetition, Practice.] To obtain the image or state of mind in all its *details* we have to apply our attention.

Recollection alone, however, is, as we have already said, not memory. It may, however, be said to be the activity that grows into it by the aid of the activity of introspection and attention.

Indentification or Recognition.

"Unconscious retention, whether conceived of as a 'holding in store' of certain cerebral habits and dynamical associations, or as a 'keeping' of ideas within a metaphysical entity called the mind, might be absolutely perfect and yet no actual memory-consciousness develop. Reproduction might be secured in perfection and might go on forever and yet no faintest shadow of a true remembrance pass within the soul. Memory, in the full meaning of the word, is a *knowing* of the *past* and of *my* past. It is *re-cognition.*"[1] Identification is thus the highest department—the final stage—of memory, for not only do we thereby assure ourselves that the object in question represents some knowledge or experience of the past, but we cognize that this past knowledge or experience was our own. It is by this faculty that we distinguish the oldest from the newest and assign the *time* and *place* of the original image, emotion or idea. In short, identification includes three factors: (1) It is a form of cognition; (2) that which is known is *re*-known, i. e., the affair is something of the past, and (3) the "something" is of *my* past—something belonging to *my* experience.

The mere reproduction of anterior states of consciousness does not represent the entire process of reproduction. We only really reproduce when we are conscious that it is *we* who had the experience. In this case we consider the idea not as the original experience, but merely as a reproduction of it.

The two main factors of identification are, therefore, the following: (1) idea of *time*, (2) identity of *me* (self).

When consciousness presents an idea it is necessary in order to recognize it that we be conscious of the fact that we

[1] Ladd. *Outlines of Descriptive Psychology.* Page 238.

have already had this idea (or experienced this sensation) in the past.

It will be seen that there is an analogy between the process of identification and that of external perception, for in order to grasp and comprehend sensations they must be subjective, and perception consists in precisely such a process, i. e., it "projects," so to speak, these sensations into space. Our word *representation* to a certain extent implies this, for it entails an idea of space—a form of external sensitivity.[2]

The mental process of identification can only be rationally explained by an acceptance of the theory that in recall the brain cells that were affected by the original experience are reaffected in the reproduction. As an illustration, let us again take the Church of St. Marco. The visual image the first time I beheld this church had, we will suppose, certain factors and characteristics—certain parts of it being clearer and more detailed than others. We will also suppose that it was two days before I again saw the Cathedral. During these forty-eight hours the image became more or less reduced and effaced. When, two days later, I again saw the church the image thereby formed was so nearly like the first image that practically the same parts of the cortex were affected. But, having already once been affected, they were affected more easily the second time. In short, the second image "found," so to speak, certain brain cells already affected,—its work was easier,—there was *recognition*. It thus resulted that the essential parts of the image (retained the first time) were reproduced in the formation of the second image, and in each case more or less the same brain cells must have been affected. Now, in view of the fact that certain parts of the brain were affected or altered the first time, less remained to be affected the second time. There was less work to be done—more room left for attention-to and refinement-of the image.

The reappearance or recall of a mental state, sensation, or image may or may not be recognizable. If recognizable, it is because there were in the mental comparison made certain factors found to be in common, or, to put it in other words,

[2]Time on the other hand is a form of internal sensitivity

the same brain cells were found to be already affected. There was a feeling of "having seen."

Various explanations exist in psychology as to the nature of the process of recognition. Notwithstanding what we have said under reproduction concerning the probability of the *same* brain paths being affected, and how under habit we gave a similar explanation, e. g., that a coat falls more easily into its old folds, it is not probable that the paths affected in recall and recognition are *exactly* the same as those affected the first time. On the contrary, it is probable that the brain tracts excited by the event at the time of its first occurrence and those excited in its recall are in part different from each other. "If we could revive the past event without any associates," says James,[3] "we should exclude the possibility of memory, and simply dream that we were undergoing the experience as if for the first time. Wherever, in fact, the recalled event does appear without a definite setting it is hard to distinguish it from a mere creation of fancy. But in proportion as its image lingers and recalls associates which gradually become more definite, it grows more and more distinctly into a remembered thing. For example, I enter a friend's room and see on the wall a painting. At first I have the strange, wondering consciousness, 'Surely I have seen that before,' but when or how does not become clear. There only clings to the picture a sort of penumbra of familiarity,—when suddenly I exclaim: 'I have it, it is a copy of part of one of the Fra Angelicos in the Florentine Academy—I recollect it there!' But the motive to the recall does *not* lie in the fact that the brain-tract now excited by the painting was once before excited in a similar way; it lies simply and solely in the fact that with that brain-tract other tracts also are excited: those which sustain my friend's room with all its peculiarities, on the one hand; those which sustain the mental image of the Florence Academy, on the other hand, with the circumstances of my visit there; and finally those which make me (more dimly) think of the years I have lived through between these two times. The result of this total brain-disturbance is a thought with a

[3] JAMES. *Principles of Psychology.* Vol. I, page 658.

peculiar object, namely, that I who now stand here with this picture before me, stood so many years ago in the Florentine Academy looking at its original."

Like perception, identification is a complex act, and necessitates the operation of several of the so-called faculties. Identification is apt to be confounded with several allied affairs or mental processes, as may be seen by comparing it with the dream, illusion, hallucination,[4] and certain acts of the imagination. We refer to a *fiction of the imagination,* such, for example, as when we are in doubt as to the occurrence of a certain action, e. g., if we have really ever had such an idea, seen such a place, or beheld such a scene. The uncertainty of the memory is notorious. How frequently do we imagine ourselves to have said things that in reality we never said? And how often do we forget having seen a certain person or witnessed a certain event when in reality we did see the person and witness the event? It has doubtless occurred to everyone to ask himself: "Is that a dream of mine, or did that really happen?"

This problem of identification is thus a double one—two questions arising: (1) In what way do we know if our identification is a true one, i. e., one of an actual former perception? (2) By what process do we distinguish the creation of our imagination? In answer to the first question we may say that there are four things to be considered, i. e., there are four factors that distinguish the real perception of an object from the mental image we may afterwards form of it: (a) When we actually perceive an object the image as it exists in the mind stands out in relief; it is alive, *vif,* and distinct. (b) The visual perception is confirmed by other perceptions, and is in harmony, and *en rapport* with it. For example, when I behold my table I see not merely the table, but the pencils and books lying on it, the chairs standing around, the effects of light and shadow, and to a varying extent the surrounding articles of furniture. To a greater or lesser extent these would be lacking in the pure visual

[4]Strictly speaking there are two kinds of sensory deception. (1) Illusion, or the false interpretation of external objects; and (2) hallucination or subjective sensory images arising without the aid of external stimuli.

image of the table as formed with the eyes closed. (c) Actual perception forces these images into consciousness, and even though we may so desire, we are unable to prevent their entrance. For example, I can, if I wish, form a visual image of my table, either with or without its books, but I cannot when I actually see the table prevent myself from seeing the books upon it. (d) The image formed by actual perception is not really capable of being modified or changed—it is not malleable. Images of the other type, however, those, for example, formed with the eyes closed, are extremely supple and docile, and can be modified with ease.

The image that arises during contemplation and meditation is felt instinctively to have been produced *within* us and *by* us. We also instinctively realize that it is modifiable at will. We feel that we have created the image in question, that it was not made for us or thrust upon us, and that we may greatly modify it at pleasure. The image is also felt to be more or less hazy and indistinct.

At times, however, the image formed may possess a clearness and vividness and stand out in relief to such an extent that it may be taken for a perception. In such cases we have what is known as an hallucination. In certain forms of insanity the image is vivid and alive to an extraordinary degree, and resists all attempts of modification.

If, on the contrary, we can modify the image as we wish; if its attachments to other ideas and images are not too strong, if it is not too clear, plain, and distinct, and especially if it is formed during a period that we instinctively feel to be one of meditation, we know that the image is one of our own invention—in short, that it is an image and not a real perception.

* * * * * * *

In Chapter I we considered memory in its relation to imagery and endeavored to show that memory, as the word is generally used, is complex in the extreme—that there are, in short, as many forms of memory as there are forms of imagery.

We also showed that in order thoroughly to examine and investigate anyone's memory we should have to examine

separately his various forms of imagery. We may, however, go further than this and say that in order to completely know anyone's memory we would also have to examine separately his powers of retention, reproduction, representation and identification.

It is difficult, nay, almost impossible, to measure these "sub-faculties" separately, and as yet we have no special method for each individual process.

In investigating the memory we have at our disposal some eight or ten methods. The four most commonly employed in psychological laboratories are:

(1) The method of description.
(2) The method of reproduction.
(3) The method of identification.
(4) The method of comparison.

It will be noted that three of these correspond to three of the four sub-faculties of memory that we have already described.

Various materials may be employed in an investigation of the memory by any one of these four methods. In the following description we shall illustrate them as they are employed when figures of different shapes are employed (such, e. g., as those shown in Fig. 1). The figures used may vary

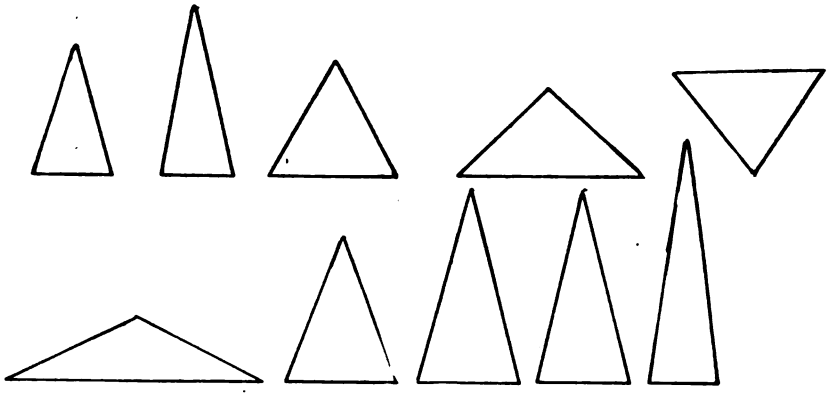

Figure 1

only in size or in both size and shape. In some cases, color also is added, but this brings in a factor that so complicates two of the methods as to make them impracticable for the purposes intended.

(1) *Method of description.* The method of description consists merely in describing from memory the figure as nearly as one can remember it. As a general rule, the description given by the subject is not very precise, and where precision is required this method should be replaced by one of the others.

With the method of description the subject is asked to *describe* the figure, i. e., he is asked to state, in terms of words, as to whether, for example, it is a triangle or square, and if a triangle, what kind of a triangle. He is also requested to state its size. This latter may be stated in terms of centimeters or inches, but it is best described by comparing it with some object already known. Intrinsically there is no objection to the subject stating the length of the figure in centimeters or inches. If he does this, however, it is probably because he has retained the size of the figure in his mind not as a figure of such or such a size, but as a figure of a certain *number* of inches in length. In other words, with this method he should not use numbers in his retention.

(2) *Method of reproduction.* The method of reproduction may be described as follows: The subject is given a pencil and paper and told to draw from memory the figure that he has seen. He may draw and re-draw as many times as he desires, make as many figures as he wishes and correct as often as he may think necessary. It will be seen that this method brings in the visual memory in a different manner from that employed in the preceding method. For here the subject is allowed to *draw,* and thus he is able to behold and visually perceive a figure that more or less approaches the original even though it may not be an exact reproduction.

It frequently happens that, although we are able to recognize an object when we see it, we may be incapable of representing it visually with the eyes closed. In such cases we may be able to recall an image of it and recognize it when we see a figure that nearly approaches it; in short, we may

"know" it in one sense of the word and yet not be able to reproduce it.

We do not mean the reader to understand that reproduction by *hand* is more difficult than reproduction by *eye*. But it is frequently impossible to place on paper the *ensemble* of visual images as introduced to the mind by way of the retina.

(3) *The method of identification.* This method consists in presenting to the subject (at the time of the second experiment) a row of figures, one of which is identical with the figure originally seen. The subject is asked if he can recognize in the group the figure observed the day previously. We may here note an important difference that exists between Methods 2 and 3. It is that in the method of reproduction the muscular sense is called into play. In order to give shape and size to the figure that the subject attempts to draw he must translate his visual image into an equivalent motor one.

(4) *The method of comparison.* This method consists in presenting to the subject a figure similar to, but not exactly like the one studied the previous day, and in asking him to state in what way the figure he studied the day before differs. He is asked to state if it was larger or smaller, thinner or thicker, longer or shorter, etc.—in short, he is asked to *make a comparison.*

It will be seen that this method is in one respect similar to the method of identification, in that it does not call into play a sensory organ other than that which was called into service at the time of the original presentation.

CHAPTER III.

THE RELATION OF LENGTH OF MATERIAL TO TIME TAKEN FOR LEARNING and THE OPTIMUM DISTRIBUTION OF TIME.

(The various Plates referred to in this Chapter will be found in the Pocket of the front cover.)

Problem 1—The relation of length of material to time taken for learning. Problem 2—The optimum distribution of time.

Complexity of Problem 1—(a) For each and every "length" various methods (both as to distribution of *time* and division of *material*) must be tried; (b) various materials must be used; (c) various methods for calculating the "amount retained."

"Once-per-day" method *versus* "continuous" method. Relation of *length of material* to *time taken* for learning found to depend largely upon which of these two methods is used.

Importance to Pedagogy of Problem 2. Length of the problem. Taking all materials and methods of presentation into consideration the most economical method is, generally speaking, to distribute the readings over a fairly lengthy period. Advisability of reviewing lecture-notes as soon as possible after taking them. Poor economy when once the original associations formed are lost.

The use of nonsense-syllables in memory tests. Difficulty of forming homogeneous sets. Rules for the formation of long sets.

In this chapter we give the results of a somewhat elaborate series of experiments undertaken to determine the relation of *length* of material to *time* taken for learning. The materials used were nonsense syllables, digits, prose, and poetry. In view of the fact that these materials were memorized by two methods, viz.,—by what we shall call the "continuous" method and the "once-per-day" method, opportunity was given to compare these two methods both as to economy[1] and durability of impression,[2] and in view of the fact that other distributions[3] of time were later used in another set of experiments, it was felt that the sum total of the results obtained on *The Optimum Distribution of Time* were sufficient to warrant putting this down as part of the title.

* * * * * * *

[1] i. e., total time taken.
[2] i. e., retentiveness.
[3] e. g., twice per week, once per week, etc.

Were one undertaking a really thorough investigation of the problem of the relation of length of material to time taken for learning, it is obvious that for each and every "length," various distributions of the study periods should be tried—i. e., not only should each prose passage, set of digits, or what not, be memorized by the "continuous" method,[4] but it should be memorized by reading twice a day, once a day, once a week, etc. Such a procedure would, of course, give us what I have termed above as "The Optimum Distribution of Time." By also varying the methods of presentation, e. g.,—reading the material to the subject, letting him read it, etc., etc.,—we would but add another contribution to the more general problem of *The Most Economical Method of Learning.* Tho this problem will be discussed more in detail later on[5] in this chapter, it will not be amiss to say a few words on it here.

Of the many factors[6] that must be considered in the problem of Economical Learning only three concern us at present—(1) the length of practice periods, i. e., how long should we study at each period? (2) Frequency of practice periods,—i. e., how often should we study? (3) Method or manner of practice,—i. e., how should we study?

Supposing now, that each of these three questions be de-

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[4] i. e., in one sitting.

[5] v. p. 81.

[6] e. g., *intensity of sound*, when material was presented aurally; *color*, when presented visually, etc., etc. These and many other such factors would have to be considered in any investigation of the most economical method of learning, if the investigation were a thorough one.

Another factor that would have to be borne in mind is that after a certain time a physiological limit is reached, beyond which further practice increases neither the speed nor the accuracy.

Most important of all, however, is the fact that what is most "economical" for one individual is not necessarily the most economical for another. Again, certain factors count more with some individuals than with others, e. g., it has been shown (Cohn. Zeit. f. Psych. Vol. XV.) that in "silent" reading, the inhibition of all articulation made a much greater difference with some individuals than with others.

Aside from *attention* it should be remembered that *interest*, or *attitude of mind*, for want of a better term, plays a considerable part. It was shown by Witasek (Zeit. f. Psych. 1907, XLIV) that active recitations of the material being memorized were far superior to the more passive readings of the material. Witasek found that long before a list could be recited perfectly, it was possible to recite portions of it, and he found that when the subject *relies upon his memory* in attempting the reproduction, (only being prompted when he hesitated) the list was learned in fewer repetitions.

cided for—say memorizing a passage of prose, it does not necessarily follow that the same procedure should be adopted for digits. Still less does it follow that it would necessarily be the best procedure for learning a language or learning to typewrite. *Individual experiments must be conducted for each and every material.* The results of many experiments have now proven to us that the so called "natural" or "psychological" method[7] of learning a language is not the most economical. It has been shown that such associations do not develop in truly natural learning—and, that any attempt to force these foreign associations into the subject's mind, retards, rather than hastens, his progress. Here, as with learning to telegraph, the natural and most enocomical method is to allow the "habits" to grow and develop together.

* * * * * * *

We shall now consider, but first from an historical point of view, the problem that it is the main object of this chapter to present, namely, the *relation between amount to be learned and time taken for learning.* I say *"time taken"* instead of *number of repetitions* (which at first thought would seem the better comparison) for the reason that we shall later compare the *total time* taken by the "once-per-day" method with the total time taken by the "continuous" method.

This problem is one that has received but little attention from the experimental psychologist. The first in the field is Dr. Hermann Ebbinghaus. Ebbinghaus[8] found that after one reading he could repeat 7 syllables; 12 syllables took 16.6 readings; 16 syllables, 30 readings, etc. The following table expresses his results in tabulated form—with certain additions of my own made for purposes of comparison that will be discussed later.

[7] We refer to the method of first thoroughly learning the various letters, then combining the letters into syllables, then combining the syllables into words, then combining the words into sentences, and finally combining the sentences into the desired thought.

[8] *Uber das Gedächtnis.* Translation by Ruger & Busenius, p. 47.

TABLE A.

Number of syllables	Number of repetitions	Difference in repetitions[10]	Time for one reading[9]	Total time[9]
7	1	..	3.5 sec.	3.5 sec.
12	17	16	24. "	102. "
16	30	13	32. "	240. "
24	44	14	48. "	528. "
36	55	11	72. "	990. "

It will be seen that the number of repetitions increases at first with great rapidity, but that later the increase becomes less and less—the increase in repetitions being relatively much greater than the increase in the number of syllables.

Binet[11] found a similar tendency. He found that 11 digits could be reproduced after 4 seconds of study; 13 took 38 seconds; while 14 took 75 seconds. Binet and Henri[12] working together obtained the following:

TABLE B.

Number of Digits	Number of Seconds
10	17
15	75
20	135
25	180
30	260
50	420
100	1500
200	4520

Offner[13] in attempting to explain such a result as the above said that it was possible that the greater the number of members in a series,—the less the attention paid to each member. This, however, would assume that each and every series demanded, and always received, a certain definite amount of attention, which would mean that the greater the number of digits, syllables or what-not in a series, the less attention each digit or syllable would receive. Offner also suggested, as a partial explanation of the relative increase in time needed for

[9]Figured at the rate of 2 syllables per second. This was not Ebbinghaus's actual rate but it is near enough for purposes of comparison with my own rate of 2 syllables per second.

[10]I. e., the increase in repetitions over that that was needed for the preceding set of syllables.

[11]Binet, *Psychologie des grands calculateurs.* Paris, 1894.

[12]Binet & Henri. *La Mémoire des Mots.* L'Année Psychol. I, 1895.

[13]Offner. *Das Gedächtnis.* Berlin, 1909.

the longer series, the fact that in a *long* series the act of forgetting has been in operation longer than in a *short* series—since it takes longer to read: hence, the greater number of repetitions required. Myers sought to explain these results on the grounds that the longer series fatigued more and that the individual members received, therefore, relatively less attention. This is somewhat similar to Offner's explanation and contains undoubtedly a considerable element of truth. It is doubtful, however, if the decrease in attention is proportionate. Ebbinghaus sought to explain his results by the narrowness of the span of consciousness and in retroactive inhibition. Although Ebbinghaus distinctly states in his preface: "The tests were all made upon myself and have primarily only individual significance"[14]—yet his "curve of forgetting" that developed from his experiments with nonsense syllables has given us what is sometimes known as *Ebbinghaus's law.* Strange to say, however, no systematic inquiry has, until recently,[15] been made to test the validity of this "law." Not only are his results quoted in nearly all the works on psychology—but conclusions, supposed to be of educational significance are drawn from them. It should also be borne in mind that on this subject Ebbinghaus's experiments were few in number. His data for 24 syllables are based on but 3 experiments; those for 36 syllables on only two.

Both Radosavljevich and Meumann noted that the change from 8 to 12, or 12 to 16 syllables, did not demand a very great increase in the number of repetitions. In fact, frequently 16 syllables were memorized with fewer repetitions than 8 or 12 syllables. The following tables (C to I inclusive) give the results obtained by various investigators of this problem of the number of repetitions required to memorize varying numbers of nonsense syllables. Excepting Table G, each table is for one, and only one, subject. As may be noted, the individual dif-

[14] *Über das Gedächtnis*—translation by Ruger & Busenius. Ruger and Bussenius touch on the point in question in their "translator's" introduction. They say, "in spite of the fact that his experiments were performed only on himself and that the numercial results obtained are consequently limited in significance, Ebbinghaus has" . . . etc.

[15] The first serious inquiry into the matter was made by V. A. C. Henmon. The results of his work were read before the American Association for the Advancement of Science at the 1911 Washington meeting.

TABLES C to I.

SHOWING NUMBER OF REPETITIONS REQUIRED TO MEMORIZE SETS OF NONSENSE SYLLABLES RANGING FROM 8 TO 72 IN NUMBER.

	TABLE C. Meumann[1]			TABLE D. Ebbinghaus[2]			TABLE E. Henmon[3]			TABLE F. Henmon[4]			TABLE G. D. O. Lyon[5]			TABLE H. D. O. Lyon[6]			TABLE I. D. O. Lyon[7]		
	No. of Syll.	Rep.	Diff.[8]	No. of Syll.	Rep.	Diff.[8]	No. of Syll.	Rep.	Diff.[8]	No. of Syll.	Rep.	Diff.[8]	No. of Syll.	Rep.	Diff.[8]	No. of Syll.	Rep.	Diff.[8]	No. of Syll.	Rep.	Diff.[8]
8	8	5		7	1											8	5		8	4	
10			2			9	10	7		10	13		10	144				30			26
12	12	10	3	12	17	7	12	8	1	12	14	1				12	69	34	12	60	30
14			3			7	14	8	0	14	15	1						7			3
16	16	17	4	16	30	6	16	9	1	16	15	0				16	83	7	16	67	4
18	18	21	4			5	18	11	2	18	16	1						3			3
20			4			3	20	14	3	20	19	3	20	138				3			3
24	24	30	6	24	44	6	24	13	—1	24	16	—3				24	94	5	24	80	7
30			1			4	30	20	6	30	26	4						5			16
32			1			2										32	103	4	32	105	9
36	36	33	1	36	55	5												5			0
40													40	174				5			1
48																48	120	7	48	107	1
72																72	306	186	72	230	120

[1], [2], [3]Experimenter using himself as subject.—Average of several trials.

[4]Average of 3 experiments on one subject.

[5]Average of one experiment on 14 subjects. Approximate only, being figured (at rate of 2 syllables per second) from the total times given in Table O.

[6]Average of two experiments on one subject, not the experimenter.

[7]Approximate only—being computed (at the rate of 2 syllables per second) from the total time given under *"continuous method"* on Plate 1.

[8]I. e.—The increase in repetitions over that which was needed for the preceding set of syllables. In order to make the various "Difference" columns uniform—i. e.—comparable—the probable amounts for each number of syllables—from 8 to 72 as given in the column to extreme left—have been inserted.

ferences are marked. The "difference" column is meant to show the relative increase, or decrease in the number of repetitions. It will be noted that with Ebbinghaus the increase is always considerable, e. g., 24 syllables take 44 repetitions, whereas 36 take 55—an increase of 11. With the same series of syllables, Meumann's increase is only 3.

It will be noted that some of these results are very different from those obtained by Ebbinghaus, for while with Ebbinghaus there is a relative increase in the number of repetitions with increase in number of syllables, with Meumann there is a relative decrease in number of repetitions with an increase in the number of syllables. "Meumann holds" says Henmon[16] "that this is what might be expected. An increase in amount of work to be done, if it is not too great, makes little difference when once the initial disinclination or inertia is overcome, when adaptation of attention is secured, when the associative processes have been aroused, and a general adjustment to the work is once attained. All of these formal conditions of learning should be effective for series no matter what their length within the limits of fatigue. Hence, it is reasonable to expect a relative decrease in energy required for learning with an increase in amount to be learned."

The results of Henmon's experiments with nonsense syllables that concern us here are shown in tables E and F in conjunction with those of Ebbinghaus and Meumann. His results differ widely from those of Ebbinghaus and Binet but are in fairly close accord with those of Meumann and Radosavljevich. There is a relative decrease in the number of repetitions as the number of syllables increases. Particularly noteworthy is the fact that the number or repetitions for the series from 10 to 18 is practically constant. The results are even more striking than those of Meumann in showing the relative economy with the longer series.

In investigating the relation of *amount to be learned* to *repetition,* Henmon also made a departure from his predecessors by using meaningful material. His results on three subjects in memorizing 1, 2, 3, 4, and 5 stanzas of *In Memoriam* by the "whole" method are given below:

[16]Op. cit.

TABLE J.

Stanzas	Words	Number of Repetitions for:— H (10)	D (10)	P (5)[17]
1	28	3	3	4
2	56	5	6	7
3	84	6	9	10
4	112	7	11	12
5	140	9	14	14

The results of my own experiments with poetry are given in Table K. Only two subjects were used. The stanzas averaged 25 words each and were of the same type as *The Ancient Mariner*. Table L gives my own individual results (as taken from Plate 3) and is placed here merely for purposes of comparison.

TABLE K.

Stanzas	Words	Number of Repetitions for:— G (6)[17]	M (6)[17]
2	60	7	5
5	150	17	14
10	300	19	16
25	750	22	16
50	1500	30	23

TABLE L.

Stanzas	Words	Number of Repetitions[18]
2	50	6
5	125	16
10	250	22
25	625	19
50	1250	25

Henmon found that the increase in the *number* of repetitions with the increase in *amount* is relatively less than the increase in the number of lines or stanzas. If the increase was proportional to the *amount* the number of repetitions would be 3.5, 7.0, 10.5, 14.0 and 17.5 instead of which the series is 3.5, 6.3, 8.6, 10.0 and 12.2, which are the averages of the three subjects of Table J. There is, therefore, according to Henmon, a relevant economy with the larger amounts. The economy in relearning after 24 hours is greater with the

[17]The figures in parentheses indicate the number of experiments from which the averages were made.

[18]Approximate only,—being computed (at the rate of 2 stanzas in 0.23 minute) from the *total time* as given under "*continuous method*" on Plate 3.

larger amounts and, according to Henmon, is relatively greater with poetry than with nonsense-syllables.

Henmon also made experiments using prose as the material. This consisted of 100-word, 200-word and 300-word passages selected from the essays of Huxley and Matthew Arnold. Sixty selections from Huxley were made, and 60 from Arnold,—20 passages of each length. One practiced subject learned 54 of these selections, (18 from each group), and recorded the number of repetitions required for learning. The results are indicated below in Table M. Table N, giving the results of some of my own experiments, which will be taken up in detail further on, is appended for purposes of comparison. In the paper read at Washington, Henmon stated only the number of repetitions. Assuming that the reading was performed at the ordinary rate (about 200 words per minute), I have taken the liberty to figure the approximate time taken for these repetitions, and have included it in Table M. It will be noted that with none of the passages do any of my subjects get so low a time as that obtained by Henmon. If his rate of reading was faster than I have assumed, the difference would be even more marked.

TABLE M.

Number of Words	Repetitions	Approximate Time
100	6.4	3.2 min.
200	7.3	7.3 min.
300	7.0	10.5 min.

TABLE N.[19]

Number of Words	Subject, with Number of Minutes Taken														
	B. B.	Ed. W.	El. W.	E. F.	E. B.	H. B.	A. K.	A. H.	E. E.	F. Wi.	B. W.	A. Q.	E. A.	F. We.	B. L.
100.....	8	10	12	14	13	16	19	15	21	17	18	17	35	31	10
300.....	25	24	19	47	40	26	29	32	37	36	51	48	78	41	28
500[19].....	42	59	67	98	103	57	88	75	..	45	133	81	*	*	54

As will be noted from Table M, Henmon finds an approximate constancy in the number of repetitions for the passages, irrespective of their length. Tho with the nonsense syllables some of my subjects gave results that approximate those ob-

[19]It should be noted that Henmon used 100, 200, and 300 word passages, whereas I used 100, 300, and 500.

tained by Henmon, with prose I get no such results as those that he obtained, as may be seen from Table N.

* * * * * * *

I have given the preceding brief summary of the results of the various investigations on The Relation of Length of Material to Number of Repetitions, not only as an historical review of those who have worked along these lines, but also because it allowed me to bring in at the same time for purposes of comparison, results obtained from certain experiments of my own. These experiments will now be considered in detail.

It was stated at the beginning of this chapter that in investigating the relation of length of material to time taken for learning we may, in the learning, use various *methods.* In the following experiments only two were used. I have designated them as (1) the "continuous" method, and (2) the "once-per-day" method. In the former the subject is allowed to memorize the material *en-masse,* i. e., in one sitting; in the latter the subject memorizes the material by reading it once a day—and once only, until memorized. The curves exhibited on the Plates, therefore, show not only the relation of length of material to time taken for learning, but they give a comparison of the total time taken to learn any passage by the one method as compared with the total time taken to learn a passage of the same length by the other method.

* * * * * * *

As may be seen from the plates, with their accompanying tables, the length of time taken to learn a passage of prose or a set of nonsense syllables, depends in large measure on the *method used* in performing the learning. In one sense of the word, therefore, it would be more fitting to call this experiment *The Relation of Length of Material to Time Taken for Learning when said Learning is Performed in one Sitting;* and, *The Relation of Length of Material to Time Taken for Learning when said Learning is Performed by the "Once-per-day" Method.*

The materials first used were nonsense syllables and poetry. With these the experiment was continued for 14½ months. Digits and prose were then substituted and the entire per-

pormance repeated. The manner of conducting the experiment was as follows:— On May 1, 1908, I memorized 8 nonsense syllables taking my time by the watch. In the evening of the same day I memorized a four-line stanza of poetry of twenty-four words. An interval of two days was then allowed to elapse. On the following day (May 4th) a similar set of eight nonsense syllables was read once. Realizing that this reading was not sufficient for a perfect reproduction, the syllables were laid aside to be read the following morning. On the evening of May 4th, a stanza of poetry similar to the one previously memorized was read thru once. A perfect reproduction of the stanza was possible after this one reading, so this finished the two sets of eight nonsense syllables and the two sets of one-stanza poetry passages, both for the "continuous" method and the "once-per-day" method. From previous work with nonsense syllables it had been found that, when memorized by the "once-per-day" method they "clung" with great tenacity, and it was deemed advisable, therefore, to allow an interval of one week to elapse before starting on the next set. Therefore, it was not until the morning of May 15th that the twelve-syllable set was started. In the meantime, however, i. e., on May 5th, a passage of poetry consisting of *two* stanzas was memorized by the "continuous" method. An interval of one day (May 6th) was then allowed to elapse and on May 7th a similar passage of two stanzas was read once and once only. Three readings were necessary to get this two-stanza passage, i. e., it was read on the 7th, 8th and 9th. An interval of one day was then allowed to elapse, after which a *three-stanza* passage was started.[20]

In this manner the experiment was continued for over fourteen months. Nonsense syllables were always read in the morning,—poetry, in the evening. After finishing each passage of poetry, whether by the "continuous" method or the "once-per-day" method, an interval of one day was allowed to elapse. With the nonsense syllables, however, a longer interval was deemed necessary—two days being allowed to elapse after each "finishing" with the "continuous" method

[20]This is all shown on plates I, II, III and IV. Plates I and II are for nonsense syllables; plates III and IV, for poetry.

and seven days after the "once-per-day" method. The reasons for making the intervals longer for the nonsense syllables are obvious. It should here be said that no other experiments on memory were conducted while this experiment was in progress, and neither nonsense syllables nor poetry of any nature was read during the entire period. To make the conditions of the experiment as scientifically accurate as possible, the nonsense syllables and poetry were taken at as widely different times of the day as possible,—the nonsense syllables being read in the morning before breakfast, and the poetry in the evening after supper. It was also deemed best to abstain from all reading for a period of at least one half hour both before and after the reading of each passage.

On June 28th, 1909, I finished with the passage of poetry consisting of 100 stanzas. On July 10th I finished with the set of 300 nonsense syllables. Feeling that the experiment had continued long enough with these materials as subject matter, I decided to repeat the experiment using this time, however, digits and prose. This new series of experiments was started on August 1st, 1909, and continued for three years, i. e., up to May 2d, 1912.[21]

The nonsense syllables were selected and made into sets after a certain definite manner.[22] A typical set is given on page 73. As may be seen from Plate 3, the poetry ranged in length from one to one-hundred stanzas both for the "continuous" method and the "once-per-day" method. The poetry selected was what is known as common meter, i. e., iambic verses in which the first line contains four feet and the second line three feet. As shown on Plate 3, however, (where the "exceptional" type is printed in red) every fourth set of poetry used had six instead of four lines in each stanza. A typical example of the first type of poetry is given below. It is a stanza from Thomas Moore's *The Ring*.[23]

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[21] This was so only for the prose. The digits were discontinued on August 10, 1910.

[22] Described in foot-note No. 40, page 75.

[23] This poem consists of sixty-two stanzas. The first 50 stanzas were used as the "50-stanza" set. As may be noted, the poem is of the same type as "*The Ancient Mariner*."

"The female fiend no sooner heard
Than, with reluctant look,
The very ring that Rupert lost,
She from her finger took."

As a typical example of the second type of poetry, I give Thomas Hood's *The Dream of Eugene Aram,*

"He told how murderers walked the earth,
Beneath the curse of Cain,—
With crimson clouds before their eyes,
And flames about their brain;
For blood has left upon their souls
Its everlasting stain!"

It will be seen that this poem is of the same type as that of *The Ballad of Reading Gaol.* My reason for using these two types of poetry was that I wanted to see if the addition of two extra lines made any material difference with either the "once-per-day" method or the "continuous" method and if so, if the difference was greater with one than with the other.[24] It will be seen from a glance at Plate 3 that by neither method does the addition of the two extra lines make any perceptible difference in the time taken for learning,—outside of the fact, of course, that the stanza takes longer to read.

For prose I decided to use selections from four different authors, alternating one with the other as shown on Plate 7. The authors chosen were Spencer, Hugo, Schopenhauer and Ingersoll. Due to the fact that I alternated one author with the other, I at first made four separate curves, one for each author. It was seen, however, that there was so little difference with the different authors that one curve was thought sufficient. The selections from Schopenhauer took a somewhat longer time, due undoubtedly to the fact that the sentences are short and that one sentence has very frequently but little logical connection with what has preceded. Personal interest in each author and his subject matter is here of such importance that this factor must be taken into consideration. This, however, was one reason for using the different authors.

Here, as in the experiment with nonsense syllables and poetry, the digits were read in the morning before breakfast

[24] Stanzas of the shorter type averaged 24 to 25 words; stanzas of the longer type averaged 35 to 40. In Plate 3 in computing the total number of words I used the figures 25 and 35 respectively.

and the prose in the evening. No passage was started until the one then in hand was finished.[25] Not only were no other memory experiments allowed, but ordinary reading was abstained from for a period of *at least* one half an hour both before and after the reading of the passage. Since, with the "once-per-day" method, only one reading was allowed each day, the actual time taken per day was very short. Where, however, the passage was memorized in one sitting, the time in the case of the longer passages was frequently very long, e. g., that for the 1500 word passage being nearly two hours. Passages longer than this were not attempted, except by the divided time method, which method was continued up to a passage of 15,000 words.

Space permits neither a detailed statement and explanation of the facts shown in the various plates and tables nor the various psychological conclusions that might be deduced therefrom. To a certain extent, however, these are self evident upon comparing the curves of the different materials with each other,—and again comparing the same materials as memorized by the two different methods. Take, e. g., Plate 8 with its tables. It will be seen that the passage of 500 words was memorized in as few days as the 250 word passage—nay, it was even one day less. But now, as the passage is twice as long, the *total* time consumed was twice as great and, therefore, the time taken varies, approximately, directly as the length of the passage. The same relation holds true for the digits and nonsense syllables but not to the same extent, for the number of days needed for 200 nonsense syllables is considerably greater than that needed for 20. By the "one-reading-per-day" method, however, it is evident that a *long* passage (or set of nonsense syllables) is learned in nearly as few days as a short passage. Referring again to Plate 8. We have noted that the 500-word passage was memorized in as few days as the 250-word passage and that, therefore, the total time varied directly as the length of the passage. Looking at

[25] It should be mentioned that in the attempted reproductions, one error was allowed for every fifty nonsense syllables or digits. In the case of the poetry one "help" (but never more than one) was allowed for every three stanzas, e. g., for the ten-stanza passage three "helps" were allowed. In the case of the prose one mistake (of one word) was allowed for every 100 words.

Plate 7, however, (which shows the curve for the "continuous" method) we observe, that, whereas the 100-word passage was memorized in 9 minutes, the 500-word passage took 52 minutes,—in other words, multiplying the passage by five, multiplies the time by six.

The red "curve" on Plates 3 and 7 show the amount of time spent on the various passages by the "continuous" method. The black curve shows the total time spent in reading similar passages by the "once-per-day" method,—the reading having been done at the rate of five minutes per 1000 words. A comparison of the two curves would show that so far as poetry and prose are concerned, one method is as economical as the other, i. e., economical as far as *time spent* is concerned for the tenacity of impression is, of course, much greater by the "once-per-day" method.

When we examine Plate 5, however, which shows two similar curves for digits we find that the "once-per-day" method is considerably more economical. The same is seen in the plate for nonsense syllables—material which, like digits, is memorized in my own case by motor associations.

As before said, Plate 3 shows (in red) the total time taken to learn by the "continuous" method the various passages of poetry ranging in size from one stanza to 100 stanzas, i. e., from 25 words to 2500 words. On the plate the *ordinates* represent the number of stanzas; the *abscissas,* the number of minutes needed. The average number of words in each stanza is about 25, except those printed in red, which average 40 words the stanza.

Plates 4 and 5 have already been touched on. It will be seen that here, as in the case of nonsense syllables, the total time taken by the "once-per-day" method is much less than is that by the "continuous" method.

The plates show that the total time taken by the "once-per-day" method is,—for the poetry and prose, nearly always as long as by the "continuous" method. For digits and nonsense syllables, however, i. e., material in which there is but little logical connection, there is a considerable saving of time by the "once-per-day" method. It may be said by way of objection that this is due to a more or less constant reviewing,

possibly unconscious, between the various readings. This is, of course, possible, but even if so does not materially alter the conclusions that may be drawn from the curves.

As we have just said, the time by the "once-per-day" method varies approximately as the length of the material. When, however, we turn to the "continuous" method, we find that this relation holds only for the shorter passages. As soon as the passage becomes too long for the mind to grasp it as a whole, the time mounts up rapidly, as shown, e. g., on Plate 7. "This is much more strikingly shown when we examine the curve obtained for the digits. Here we see that although it took only 5 minutes to learn 24 digits, it took 2 hours and 34 minutes to learn 200—more than 31 times as long instead of 8. In short it is obvious that the "once-per-day" method is—to say nothing of giving a far superior retention—far more economical than the "continuous" method. This is especially so for material memorized by motor associations such as nonsense syllables or digits." [26]

One thing, probably the most important, that may be said in favor of the "once-per-day" method so far as economy is concerned, is the fact that material memorized by this method is retained for a much longer period than that memorized by the "continuous" method. This is probably its chief, if not its only advantage.

As no other subject was available who would undertake all of the various tests just described, I have no complete curves for comparison. I have, however, the records[27] of six subjects on various parts of the test, e. g., one subject memorized a 500 word passage by the "continuous" method and then memorized it by the "once-per-day" method. Another subject memorized 48 nonsense syllables by the "continuous" method, 100 digits by the "continuous" method, a passage of 500 words by the "continuous" method and 30 stanzas by the "once-per-day" method. Space does not admit an entire reproduction of the records of these six subjects.[27] As one would

[26] D. O. Lyon. *The Relation of the Length of Material to Time Taken for Learning*, Journal of Philosophy, Psychology and Scientific Methods, Vol. IX, No. 14.

[27] Some of these have already been given in Tables G, H, K, and N.

expect, however, in an experiment of this kind, the various subjects differed greatly.

On another set of students[28] (fourteen Normal College girls) a somewhat different test was tried, the results of which, since they take but little room and are valuable for comparison with some of the preceding tables, are given on the following page.

Of the various individual differences in the group of six referred to on the preceding page, I found the greatest to occur with digits and nonsense syllables when memorized by the "once-per-day" method. I mean by this that the results obtained for memorizing such material by the "once-per-day" method differed more widely from the "continuous" method (in my own case) than did prose or poetry. To elucidate this fact, I give in Table P, the results of a certain experiment. Briefly stated, this experiment was as follows:

Sixteen subjects were selected from a list of over 100 as having averaged the best in a certain miscellaneous set of memory experiments. Ten of the sixteen subjects[29] occurred in the group of fourteen referred to on the preceding page. These sixteen names were then mixed up and eight selected at random for work on digits. The remaining eight were allotted prose. Of the eight digit-subjects, four were given a set of fifty digits, the other four were given a set of 200 digits. Of the eight prose-subjects, four were given a passage of prose 250 words long and the remaining four were given a passage of prose 1000 words long. The subjects were then read the directions and rules of the experiment. Briefly stated these were that the subject would be called on to read the material allotted her once a day, and once only (Saturday and Sunday included) until she felt confident she could write the passage without error. The method of scoring these re-

[28] These fourteen students were selected from the Junior and Senior classes of the Albany Normal College and were selected as being the fourteen foremost out of over sixty students, i. e., they stood highest in their general average in class.

[29] All the subjects were girls. They averaged in age from 19 to 23.

TABLE O.

1	2	3	4	5	6	7	8	9	10
Subject	Material Used.								
	Nonsense Syllables			Digits			Prose		
	10	20	40	20	100	150	100	300	500
B. B.....	5 min.	10 min.	28 min.	3 min. 15 sec.	57 min.	1 hr. 54 min.	8 min.	25 min.	42 min.
Ed. W.....	5 min.	12 min.	31 min.	3 min.	46 min.	1 hr. 19min.†	10 min.	24 min.	59 min.
El. W.....	6 min.	13 min.	36 min.	2 min. 30 sec.		1 hr. 55 min.	12 min.	19 min.	1 hr. 7 min.
E. F.....	7 min.	12 min.	37 min.	6 min.	54 min.		14 min.	47 min.	1 hr. 38 min.
E. B.....	11 min.	20 min.	45 min.	8 min.	1 hr. 11 min.		13 min.	40 min.	1 hr. 43 min.
H. B.....	13 min.	24 min.	58 min.	4 min.	1 hr. 37 min.		16 min.	26 min.	57 min.
A. K.....	12 min.	23 min.	38 min.	7 min. 30 sec.	58 min.	2 hr. 16 min.	19 min.	29 min.	1 hr. 28 min.
A. H.....	15 min.	29 min.	1 hr. 10 min.	6 min.	1 hr. 17 min.		15 min.	32 min.	1 hr. 15 min.
E. E.....	12 min.	18 min.	51 min.	9 min.	1 hr. 3 min.		21 min.	37 min.	
F. Wi.....	16 min.	27 min.	1 hr. 17 min.	5 min.	1 hr. 22 min.		17 min.	36 min.	45 min.
R. W.....	17 min.	31 min.	1 hr. 39 min.	7 min.	*		18 min.	51 min.	2 hr. 13 min.
A. Q.....	13 min.	34 min.	2 hrs. 4 min.	10 min.	*		17 min.	48 min.	1 hr. 21 min.
E. A.....	17 min.	37 min.	57 min.	11 min.	*		35 min.	1 hr. 18 min.	*
F. Wo.....	16 min.	36 min.	*	4 min. 45 sec.	2 hr. 16 min.		31 min.	41 min.	*
Aver.	12 min.	23 min.	58 min.	6 min. 34 sec.	1 hr. 14 min.	1 hr. 51 min.	18 min	38 min.	1 hr. 17 min.

*Given up after 2 hours.

†This subject's time for 200 digits was 1 hr. and 49 minutes.

productions and the methods of deducting for attempted reproductions that were not perfect enough to consummate the experiment, was somewhat elaborate. Suffice it to say that the scores given were made on a percentage basis of *perfection = 100*. It was directed that the subject read the passage at her usual rate of reading, thoughtfully, i. e., understandingly and either aloud or to herself as she preferred.

Table P gives the results of this experiment. They are somewhat different from what I had been led to expect and in one sense of the word, considering that the subjects were all "selected," are somewhat disappointing. It will be noticed that of the eight subjects assigned prose, all but one finished.[20] The average number of days for the subjects using the 200-prose passage was 29 days. The average time taken for those reading the 1000-word passage was 48 days.[21] Were the subject E. S. to be excluded the number would, of course, be lower. All of the subjects using the set of 50-digits finished within the 60 day limit; their average time is 41 days. With the 200-digit group of subjects the results were rather unsatisfactory. They were certainly (with reference to the experiments on myself) most unexpected. As will be seen from the table, only one of the four subjects, was able to reproduce satisfactorily[22] the set of 200-digits within the time limit. The remaining three were requested to write down as much as they were able of the material so that a score of some sort could be placed on their attempted reproductions. As shown on the table, their scores are fairly high.

[20]Force of circumstances necessitated a discontinuance of the experiment after 60 days.

[21]Including the subject E. S. by using her "score" in the calculation.

[22]Space does not permit here giving the method of scoring the reproductions. Suffice it to say that with the set of 50 digits a perfect score was 100 and with the 200-digit set, 400. An error of 4 points was allowed for the 50-digit set and 16 points for the 200-digit set. As previously explained, it is undesirable for many reasons to insist on a perfect reproduction. In fact in general it is best in memory experiments, where a comparison between the individuals is to be made, to continue the experiment only until the first subject has "finished," and then grade the others accordingly.

TABLE P.

1	2	3	4	5
Subject	Material	Days	Average No. Days (Using Column 5 in the calculation)	Score at Expiration of 60 days[32]
E. F.	50 Digits	40	41	
A. K.	50 Digits	37		
E. A.	50 Digits	48		
F. Wo.	50 Digits	39		
Ed. W.	200 Digits	*		92
B. B.	200 Digits	51	68	
El. W.	200 Digits	*		84
A. H.	200 Digits	*		67
E. B.	200 Prose	27	29	
F. Wi.	200 Prose	36		
A. Q.	200 Prose	24		
F. S.	200 Prose	28		
H. B.	1000 Prose	40	48	
E. E.	1000 Prose	49		
R. W.	1000 Prose	28		
E. S.	1000 Prose	*		89

The most interesting fact, however, is that at the end of 40 days—the scoring of an "attempted reproduction" of these three subjects gave figures nearly as high.

* * * * * * *

As was stated early in this chapter, these two "methods"[34] of memorizing contribute but a small fragment to the much larger problem of the *Optimum Distribution of Time*[35]—a problem which is but a minor contribution to the still more general problem of *Economy in Learning*. Such a problem, as we have already said, would have to consider not only the various subdivisions of time, subdivisions of material,

[32]At the end of 60 days, those who had not completed the experiment were requested to write down as much of the prose passage, or set of digits, as possible. These reproductions were then "scored" on a percentage basis of "Perfection = 100." From these scores the probable number of days was then calculated in order that this might be used in calculating the "Average Number of Days" in Column 4.

[34]i. e. the "continuous" method and the "once-per-day" method.

[35]It has been proven by experiment that a certain effort expended at intervals over a period of several days will give better results than if this same effort is expended in one "sitting." We do not, however, know the most effective distribution possible,—nor do we know whether this "most effective distribution,"—supposing it had been ascertained,—would apply to one material as well as to another. It has been proven that in general it is better if, say *one* hour is to be spent on a list of 40 nonsense syllables, to divide this hour up into sections, but the most favorable distribution has never been determined.

nature of material, time of day, etc., but would have to include an investigation of such things as,—loud v. silent reading, fast v. slow reading, etc., etc.

As a matter of fact, no single method can be set down as being the most economical for everyone. The problem is not, *What is the most Economical Method?*, but *What is the most Economical Method for Mr. Brown and how can he find this method out?*

This problem of the most favorable subdivision of the MATERIAL, or the most economical unit for committing to memory, is not one that has received the attention of many investigators. The various phases of this subject have been taken up by Steffens, Pentschew, Schneider, Larguier des Bancels, Pyle, Snyder, Jost, and Lakenan. Steffens found that it was better not only not to divide a stanza of poetry into parts, but that for poems of moderate length it was better not to divide the poem into stanzas. Schneider says that even for poems of 12 or 15 stanzas, the "best" (and as a rule he means by this the most economical) method is to read and re-read the entire poem.

A problem of even greater importance than the optimum subdivision of the material is the optimum distribution of TIME. Though of great practical importance, the problem has received but relatively little attention. The best and most recent work here is that performed by Pyle* on ten subjects with the typewriter. Five subjects worked for ten half-hour periods a day, with half-hour rests between the practices. They worked nine successive days—putting in 90 one-half hours, i. e., 45 hours in all. This group Pyle called the "Fast group."

Five other subjects worked for two half-hour periods a day, one in the morning and the other in the afternoon. This group also put in a total of 45 hours, and was termed the "Slow group." Pyle concluded that distributed practice is the best, although "concentrated practice brings in good returns, and if one is in a hurry to acquire a skill, the diminished returns

*"Concentrated Versus Distributed Practice." *Jour. of Ed. Psychol.* 1914. Vol. V, pages 247-258.

for concentrated practice need not be considered prohibitive."**

Such conclusions should not be taken to necessarily apply to the learning of prose or poetry, but they may apply, as Pyle very justly remarks, to kindred actions, such, e. g., as learning to play the piano.

In another set of experiments, where 26 characters were used—these being learned in place of the 26 letters of the alphabet, Pyle† arrives at similar conclusions. "In habit formation," says he, "an adult can practice profitably for something like 30 minutes daily. The length of time for practice doubtless varies with individuals and with the stage of fixation of the habit. If practice is extended beyond 30 minutes, there may be some return for the extra time, but it is relatively small. It is quite probable that in the latter stages of habituation the length of the practice period could be shortened and the interval lengthened with practically as much return. A second practice on the same day is not quite as beneficial as the first practice. After a few practices, further practice on the same day is useless. The next step in the experimental study of the economy of learning should be to determine the relative value of practice of every length of period from one minute up to one hour."

Strong†† from a series of experiments performed with pictorial advertisements concludes that "of all intervals between successive repetitions, that of a day's length will give us our maximum results, and those of a few minutes and of a week are much superior to that of a month." The material used by Strong, however, was somewhat unique, and it is not to be inferred that his conclusions must necessarily apply to such materials as prose and poetry.

Although these various investigators had, as a rule, *economy in learning* in mind, they limited their experiments to such a narrow phase of the problem, or conducted them along such different lines, that the results they obtained do not easily lend themselves for comparison with our own. Exception might

**Op. cit.*, page 258.

†"Economical Learning," *Jour. of Ed. Psychol.* 1912. Vol. III, pages 148-158.

††"Two Factors which Influence Economic Learning," *Jour. of Philos. Psychol. and Scientific Methods.* 1914. Vol. II, page 131.

be made in the case of Steffens and also of Jost. The work of Steffens will be taken up in the next chapter. Jost's experiments, so far as they go, are in several particulars similar to our own, and a brief summary of them here may not be out of place. Jost's experiments purpose to answer the following questions: (1) Given a list of syllables to learn by heart, what distribution of time will give the best retention? (2) Is the once-per-day method more economical in "time spent" than the continuous method, and how do results compare as to the "length-of-time retained?" For example, is it best to read over the series of syllables thirty times on one day, or ten times a day for three consecutive days, or twice a day during a period of fifteen days? Unfortunately, Jost's experiments were not performed on a very extensive scale. The material was limited to nonsense syllables (in lists of a dozen syllables each). Also the subjects were but two in number, and the results, therefore, are but of a limited value. Unlike my own experiments, as described later on in this chapter, Jost's experiments cannot be said to compare the *continuous* with the *once-per-day* method. They compare the *continuous* method with the *ten-per-day,* or *twenty-per day,* or *x-per day* method. For example, a subject was given a set of syllables and allowed to read them twenty times; the next day he was presented with the same set and directed to read them until he knew them, the number of readings being taken by the observer. (We will suppose that five extra readings were necessary.) He was then given an entirely new set of syllables, and the number of readings required to memorize these was compared with the number required to learn the set that had been read twenty times the day previously. If, for example, the new series took 50 readings, whereas the first series had taken only 25 (20 + 5) readings, Jost concluded that the first method had resulted in an economy of 50 per cent.

For our present purposes with reference to *economy in learning,* Jost's experiments on the *optimum distribution of readings* are interesting. They undertake, for example, to answer such a question as the following: Which is the most economical, thirty readings made in one day or ten readings a day during a period of three successive days? With one of his subjects Jost found that the number of repetitions neces-

sary in order to relearn a series that had been repeated thirty times in one day was on the average 6.5, while in order to relearn what had been repeated ten times a day during a period of three days the subject required only five repetitions. With his other subject the figures were 11.5 for the first learning and 9.7 for relearning. Jost therefore concluded that there was a marked saving of time with the second method, i. e., that ten readings per day for three days was more economical than thirty consecutive readings.

* * * * * * *

Space does not allow publication of all my own data, but sufficient have been given to illustrate the nature of the experiments made. The *conclusions* drawn, however, are of greater significance, and we give the more important of them below. It should be understood that in their determination the data included not only those obtained from the experiments that will be discussed in the next chapter, but the written introspections of over five hundred subjects:

1. For meaningful material such as prose or poetry the total time consumed by the "once-per-day" method is about the same as that needed by the "continuous" method. With both methods with passages of 1000 words or less the time varies directly as the length of the passage.

2. With nonsense syllables, digits, and all material memorized by motor associations the total time spent by the "once-per-day" method may be roughly said to vary as the length of the passage; by the "continuous" method, however, the time would seem to vary approximately as the square of the length of the passage.

3. Visual presentation would seem to be better than auditory presentation, but a combination of the two, e. g., when the subject reads his own material aloud, would seem to be more economical and to give greater retentiveness than either. The superiority of visual over the auditory presentation would *not* seem to be alone due to the fact that two senses instead of one are called into play, but because we can read more easily and more exactly than we can hear;—a third reason is that visual presentation allows us to choose our own rhythm and rate of reading.

4. Things that make sense, i. e., meaningful material, are

learned in larger units than non-meaningful material. The subject is able to take the material as a whole for the reason that it is logical, i. e., that it means something to him. In one sense of the word, one might say that with meaningful material the subject has already (i. e., previous to the experiment) memorized a large part of it.

5. Subjects who have lately been taught mnemonic systems are apt to over-do them, i. e., they endeavor to apply them more often than is for their own good. Mnemonics only pay when very easily formed and when easily remembered. Very often the task of forming associations and the difficulty of remembering them is greater than would have been the task of using, what we might term for want of a better expression, "brute memory," i. e., to memorize a fact by *knowing* it.

6. With nonsense syllables, not only does one have to learn the constitution of the individual syllable, but the order of the syllable as well. For words, *order* is practically the only thing necessary, provided, of course, that associations between the words have been formed.

7. With reference to the problem of the *most favorable distribution of single readings,* referred to several times in the preceding pages, I would say that "the most general statement that can be made, taking all materials and methods of presentation into consideration, is that the most economical method is to distribute the readings over a rather lengthy period,—the intervals between the readings being in arithmetical proportion. For example, with one individual in memorizing a poem of 20 stanzas the highest retentiveness was obtained by distributing the readings as follows: 2 hours, 8 hours, 1 day, 2 days, 4 days, 8 days, 16 days, 32 days, etc. The practical bearing of the results obtained on education in general" [86] is that when associations have once been formed they should be recalled before an interval so long has elapsed that the original associations have lost their "color" and cannot be recalled in the same "shape," time, and order. In general it was found "that the most economical method for keep-

[86] D. O. Lyon. *The Optimal Distribution of Time, and the Relation of Length of Material to Time Taken for Learning.* The Journal of Philosophy, Psychology and Scientific Methods, Vol. IX, No. 14.

ing material once memorized from disappearing, was to review the material whenever it started to 'fade.' Here also the intervals were found to be, roughly speaking, in arithmetical proportion. For similar reasons the student is advised to review his 'lecture-notes' shortly after taking them, and if possible, to review them again the evening of the same day. Then the lapse of a week or two does not make nearly so much difference. When once he has forgotten so much that the various associations originally made have vanished, a considerable portion of the material is irretrievably lost." [37]

In this connection we cannot do better than quote from Dr. Garry Myers' article entitled "Recall in Relation to Retention." *

"Simple recall of stimuli wholly or partially learned aids in their retention. Teachers and pupils would profit greatly by frequent recalls of things they have learned, while the material is fresh in mind, rather than have long and arduous reviews that require an extensive re-study of the material once learned. There should be more frequent but shorter reviews, reviews that demand little or no extra study, but a recall of materials already learned. It is often the custom in our secondary schools and colleges to give examinations after long intervals of one, two, three or more months. The students often go through cruel and torturous processes of cramming and after the examination is over are happy to forget about what they learned. A five or eight minute test given unannounced, demanding recall of the things recently learned, as well as those more remotely learned, with a final survey-test of the whole field studied, will aid the student to master a subject with little or no conscious effort at re-study. In fact, this would be merely an application of the laws of apperception in the process of learning.

* * * * * * *

The time taken to memorize nonsense-syllables as found by the various experimenters who have worked with them, is far from being always the same, even when the subjects are of the same age and intellectual standing. An examination of

[37] Op. cit. page 386.

* *Jour. of Ed. Psych.* 1914. Vol. V, pages 128-129.

the various sets of nonsense syllables used by these experimenters has proven to me that this difference in time is largely due to the great differences in the difficulty of the nonsense syllables used.[38] Experiments of my own have confirmed this.

Were one to attempt to repeat the prose experiment, the results of which are given in Table O, he would arrive at approximately the same results if he used bright students, say the best quarter of a class of 60 or 70, even though he selected his prose passage at random from any novel.[39] It is probable that with digits also, his results would be much the same. When, however, he came to nonsense syllables, his results would be liable to differ widely unless the sets of syllables used were equal in difficulty to those used by me. I give below the set of 40 syllables used in the experiment in question and would advise their use should anyone attempt to repeat the experiment for purposes of comparison.

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KUV	ZID	KIF	NUZ	POZ
YAB	VEL	HEB	BOF	NIV
SEF	NAZ	YIF	JEP	DUT
BUP	JID	KEV	VOB	KEL
KED	LUP	NAD	FEG	VUM
TIB	MIV	TEF	YAB	JOP
WEF	VOB	KIV	VUZ	BAV
BOL	RUZ	JED	DIB	NID

[38] As an example of what I mean, I here give an example of a series of nonsense syllables as given by Watt in a footnote in his book entitled "*The Economy and Training of Memory.*"

"Bax, goul, fos, hiv, ped, vaub, jum, cor."

It is obvious that with such a set of nonsense syllables associations are very easily formed, e. g., with one individual these 8 syllables were memorized in 1¾ minutes by using the following words in place of the syllables which they so nearly resemble:

Box, ghoul, "fossa," live, pedestal, vault, jam, body;—

all these being easy of recall in their proper order by visualizing a picture of a ghoul at work in a cemetery.

[39] My own prose passage with the group of 14 Normal College Students was taken from Dewey's *School and Society.*

Short sets of nonsense syllables are easily made,—repetitions of syllables being easily avoided. There are, for the English language, only about 90 fairly good nonsense syllables, and of these nearly 80 begin with J or N, end with B or D, or have O or U as their vowel. In making a series of say 40 nonsense syllables, from the 90 possible ones, it will be found, *if the rules given in the footnote below*[40] *are followed,* that after the list has grown to 25 or 30, more than half of the syllables drawn have to be thrown back. Lists of 60 or more are made only with considerable difficulty, and it is frequently found necessary to throw the syllables back[41] and start over again. Sets of 90 syllables or over must contain either a certain number of undesirable[42] syllables or a number of repetitions. For example, the set of 104 used by me with the "once-per-day" method contains three "DUT"s, two "BOF"s, two "POF"s, and two "ZIM"s;—not that these repetitions could not have been avoided, but their avoidance would have necessitated either the use of certain undersirable syllables, or a recasting of a large part of the entire set. This set of 104 syllables is given below:

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[40] Rules for forming sets of nonsense syllables from the 90 nonsense syllables previously selected:—

1. Syllables must be drawn by chance.
2. Initial consonants must not be the same unless separated by two or more syllables.
3. End consonants must not be the same unless separated by two or more syllables.
4. Vowels must not be the same unless separated by two or more syllables.
5. The initial consonant of one syllable must not be the same as the final consonant of the preceding syllable.
6. Excepting sets of 72, or over, syllables may not be repeated.

[41] My method was to mix up the syllables in a box and draw them out at random—arranging them one under the other. Whenever a syllable was found to violate any of the above rules it was thrown back.

[42] By "undersirable" syllables I mean syllables that (1) are difficult of pronunciation, e. g., YUF; or (2) that permit of quick and easy associations, e. g., LUK.

MIV	VUD	LUD	JED	NOL	NAV
ZAD	FEV	FEG	KOV	PAB	FUD
PIB	ZIB	DUT	SEB	LIR	PEM
KED	LOD	KIB	TID	JEP	BOK
LUP	JAZ	NAZ	YUP	KOV	
TAV	POF	BOD	RUZ	TID	
NID	DUT	JEP	KEV	BUP	
HEB	BOV	WIB	YIM	YAB	
VUS	ZIR	NUZ	NUV	ROZ	
ZIM	VEL	ROV	JAD	HEB	
KUV	PID	YID	POZ	NIV	
JID	JUR	TEF	LEB	SEF	
BOF	NAD	BOZ	TID	BOL	
YAB	VOB	PEV	FEK	ZIM	
WEF	YIF	JUF	RUL	VED	
DIB	TEB	VIB	BOF	NAZ	
JAL	JOD	NAJ	ZID	DUT	
HUF	ZUB	FEK	YAB	POF	
NIZ	NIV	HUZ	SEF	VUM	
TOB	KOB	BOP	HUV	JOP	

CHAPTER IV.

THE RELATION of QUICKNESS OF LEARNING to RETENTIVENESS

WITH SPECIAL REFERENCE TO THE TREATMENT AND MANIPULATION OF THE DATA AS OBTAINED BY EXPERIMENT.

Historical review of literature on the subject.
The various methods and means of determining retentiveness—the various methods possible; the various materials possible of use. Classes of subjects tested.
Presentation, Examination, and Method of Scoring of the results obtained—with—digits, nonsense syllables, words, prose, and poetry.
Analysis of the Results, and Inferences Drawn, as to:—
- Time of Initial Learning.
- Interval between presentation and reproduction.
- Method One.
- Method Two.
- Method Three.
- Intellectual Standing (Mental Ability).
- Social Standing (Occupation, Environment, and Moral Standing).
- Age.
- Sex.

Summary and recapitulation of the main results.

The history of scientific inquiry concerning the relation of quickness of learning to retentiveness, and, for that matter, nearly all experimental work on memory, dates back only thirty-seven years. Before 1880 experimental psychology had confined itself largely to reaction times and sensations, but with the publication of Ebbinghaus's "Über das Gedächtnis"[1] in 1885 experimental work on memory acquired an impetus that has ever since been on the increase. Ebbinghaus worked on many phases of the memory problem, and for his experiments used both meaningful and meaningless material. The material chosen by him for his experiments consisted of about 2300 nonsense syllables, made and selected as follows: From the simple consonants and the eleven German vowels and diphthongs he formed all the meaningless syllables

[1]An excellent translation of this monograph has recently been made by Ruger & Bussenius, under the title "Memory." It comprises Educational Reprint No. 3 of Teachers' College, Columbia University.

possible by placing a vowel or a diphthong between two consonants. These lists of nonsense syllables were then shuffled and drawn by lot. Ebbinghaus preferred these "nonsense syllables" to words because of their relative simplicity. The remark is often made, however, that nonsense syllables are not simple, and that, on the contrary, they are in some respects as complex as words. Ebbinghaus himself remarks that something more simple would be desirable, for the reason that the learning of nonsense syllables involves not only the sense of sight and hearing, but the muscular sense of the vocal organs (tongue, lips, etc.). Moreover, not only do nonsense syllables *not* possess equivalent tendencies to set up association processes, but certain lists of syllables that may appear equally difficult to one individual may appear very unequal to another. Even supposing that nonsense syllables when carefully selected and arranged *do* furnish subject-matter sufficiently homogeneous when presented to a single sense, it does not necessarily follow that the same material when presented to a *different* sense will *continue* to be homogeneous. But, with all their faults, nonsense syllables are preferred by many psychologists to words, prose or poetry for testing the "organic memory." Words are apt to form associations too easily, especially with some individuals; and prose and poetry are far from being homogeneous, in that they are constantly changing in character. This is especially the case with those individuals in whom "interest" is so essential that material not "interesting" to them is practically impossible of memorizing. Though it is true that many of the nonsense syllables used by Ebbinghaus were such as to allow numerous associations, his experiments were so conducted as to preclude to a considerable extent the forming of these associations—in fact, with Ebbinghaus they were seldom formed. Another advantage in the use of nonsense syllables is that they afford an almost unlimited number of combinations of a *similar* character and quantity. Nevertheless, nonsense syllables have so many objections not carried by digits that it is

a question as to whether the latter would not really be better for the testing of "organic" or "rote" memory.

In his monograph, "*Über das Gedächtnis,*" Ebbinghaus groups his experiments under the five following headings: (1) Rapidity of Learning Series of Syllables as a Function of Their Length. (2) Retention as a Function of the Number of Repetitions. (3) Retention and Obliviscence as a Function of Time. (4) Retention as a Function of Repeated Learning. (5) Retention as a Function of the Order of Succession of the Members of the Series. His main experiments that concern us here may be considered under two heads: (1) The dependence of the rapidity of learning a list of nonsense syllables upon the length of the same. (2) The relation of retention to the number of repetitions.*

Ebbinghaus gave much attention to the details of his experimentation. His method was to repeat the syllables aloud until he could voluntarily recall them. He considered that he "knew" them when he was able to repeat the series correctly, in a given time, after the first syllable had been supplied. A series was read through once from beginning to end without stopping, and then, upon the first syllable being supplied, the attempt was made to repeat the entire series, stopping, however, at the first hesitation. At this first hesitation the remainder of the list was read, and the entire repetition was started again. The syllables were read and repeated at the rate of 150 per minute and in a uniform tone. The rate was secured by timing the reading by the ticking of a watch or by the strokes of a metronome. Upon a series being completely memorized, Ebbinghaus made a pause of 15 seconds for noting the results, after which he immediately started in on another series. No attempt was made to form logical associations, the speed being so great as to practically preclude this. Ebbinghaus took great care that all the conditions would be such as to favor attention; his environment was such as to favor concentration, and in case of ill-health the experiment was deferred.

Though Ebbinghaus did not specifically attack the problem

*Ebbinghaus's experiments on the relation between the amount to be learned and number of repetitions have been discussed in Chapter III.

of retention as related to speed of learning, some of his experiments are fundamental in considering this problem. It should be understood that he experimented only upon himself as subject, and that his results have, therefore, in the first instance, only individual validity; but it should also be remarked that he tested every point in many trials, and that he was, undoubtedly, an unusually steady and trustworthy subject for experiment.

One of his results that is pertinent to our study concerns the effect on retention of varying amounts of time devoted to the original learning. He found, as we would naturally expect, that the greater the number of repetitions, within certain limits, the better the retention. To determine the effect of many repetitions upon retention he repeated a series of 16 syllables a definite number of times, and then noted how many repetitions were required 24 hours later to complete the learning. He found that about one-third of the labor was saved by the repetition of the day before. According to him, three repetitions to-day save one tomorrow, or, in other words, for every three times a person repeats such a list to-day he will save one repetition 24 hours later. This was true, whether the number of repetitions on the first day was barely sufficient, more than sufficient or less than sufficient to enable the series to be immediately recited.

In a general way this same result applied also to the retention of syllables of differing length, learned at first to the point of correct recitation. As would be expected, it required a longer time to learn a long series than a shorter one. Ebbinghaus found that, as a rule, he could repeat a series of seven syllables after a single reading; about seventeen readings were required for a series of twelve syllables, and nearly thirty readings for a series of sixteen. But on testing twenty-four hours later he found that the longer series were the better retained. The additional work demanded by the long series had an enduring effect, most easily explainable on the ground that part or parts of the series had been over-learned.

Ebbinghaus found that the value of each repetition for purposes of retention was greater when the various repetitions were distributed over several days than when concentrated into

a single study period. Thus, in one series of experiments he learned 12-syllable series on one day and relearned them on the three succeeding days. The average number of readings required for an errorless recitation was 17.5 the first day, 12 the second day, 8.5 the third day and 5 the fourth day. In another experiment he continued reading 12 syllables beyond the time necessary to learn them, *i. e.*, the number of repetitions was greater than that needed for an errorless repetition. If the syllables were repeated only 8 times on one day, they were not known the following day, nor could they even be recognized as the list studied. If given 68 repetitions, however, they *could* be recognized the next day, although the series could not be given, for, on relearning the series 24 hours later, 7 repetitions were required. On comparing the two facts as given above it will be noticed that in the first case 38 repetitions, distributed over three days, needed on the fourth day only 5 repetitions, while 68 readings on one day needed, even on the very next day, 7 repetitions.

Ebbinghaus's studies on the rate of forgetting are now almost classic. He found that forgetting, while relatively rapid at first, later on proceeds more and more slowly, and, in his judgment, nothing once learned is ever absolutely forgotten. He found that after an interval of one hour so much had been forgotten that more than half the time originally expended had again to be given to the work in order to relearn it. After eight hours almost two-thirds of the labor must be repeated. From this point it would seem that the process of forgetting proceeds more slowly. After twenty-four hours two-thirds of the original labor must still be performed, *i. e.*, the "impression of the whole" retains about one-third of its original strength. The change now becomes still slower, for even after six days one-quarter is still retained, and after a month one-fifth. "It is noteworthy," says Burnham, "that, while the impression made by nonsense syllables is so evanescent that a series once perfectly learned is forgotten after an interval of twenty minutes, a residuum of some sort persists for a long time, so that even after a month the same series can be relearned in four-fifths of the time originally required. A general statement of the results is as follows: The ratio of what

is retained to what is forgotten is inversely as the logarithm of the time."

Thus far we have considered only those experiments of Ebbinghaus in which the material used was nonsense syllables. We shall now turn our attention to the experiments in which he used *logical trains of thought.* For this work Ebbinghaus used stanzas from Byron's "Don Juan." He found that the time taken to learn a stanza was only one-tenth as long as that needed for a list of nonsense syllables equivalent in number to the number of syllables in the stanza. In other words, material connected by the bonds of sense and rhythm needed only one-tenth the number of repetitions required by material *not* so connected. Not only was the meaningful material more speedily learned, but it was also better retained. The number of readings required after 24 hours for both sense and nonsense material may be seen in the table given below. It is illustrative also of what Ebbinghaus termed his "saving method."[2]

Material Used.	No. Readings Required to Learn.	No. Readings Required to Relearn.	Per Cent. Retained. (Calculated.)
12-Syllable series.....	16.5	11	33
24-Syllable series.....	44	22.5	49
36-Syllable series.....	55	23	58
Stanza of "Don Juan".....	7.75	3.75	52

Meaning, i. e., amount of sense to the material, is thus seen to affect both *speed of learning* and *retention* in the same way, favoring quick learning and tenacity of retention.

Another factor that affects the above two factors in the same way is the speed of reading. Ebbinghaus reports experiments[3] in memorizing stanzas of Schiller's translation of the Aèneid at the rate of 200, 150, 120 and 100 iambics per minute. At these rates he learned the same number of lines in 138, 148, 160, and 180 seconds, respectively, thus proving that the amount of time required varied inversely as the speed of reading. On relearning these lines twenty-four hours later he found that 90, 89, 96 and 99 seconds were required, thus showing, as far as permanence is concerned, a slight difference in favor of the more rapid rates. In performing these experiments, how-

[2] Ersparnismethode.—See "Method 3." page 99.

[3] "Grundzuge der Psychologie," 2d ed., 1911, pp. 672-673.

ever, Ebbinghaus did not consider the *degree of exhaustion* produced by the different rates.

It is true a greater number of repetitions is required with the rapid than with the slow rates. He concluded that the fastest rate of reading is the most economical as concerns the speed of learning. In order to test the retention as well he relearned the stanzas twenty-four later, this time at the rate of 150 iambic feet per minute for all the stanzas. He found that the stanzas that had been originally read at the greatest speed and learned in the least time were also, on the whole, slightly better retained than those that had been read more slowly. After an interval of 8 days he again repeated this test with the same result.

In 1887 G. E. Muller and F. Schumann,[4] stimulated by the work of Ebbinghaus, set out to repeat his experiments on a more elaborate scale, making, however, certain changes in method and material. Their labors extended over a period of five years (1887-1892, inclusive). The only fundamental difference between their experiments and those of Ebbinghaus was that they did not let the subject know the purpose or result of the various experiments, a thing obviously impossible where the experimenter uses himself as subject. The material used consisted of nonsense syllables similar to those used by Ebbinghaus, but selected with greater care, and instead of being read directly from the sheet of paper on which they were written, and where they could all be seen at once, they were read from a revolving drum through a slit in a screen. The drum from which the syllables were read was allowed to revolve at different rates in the various experiments. The three rates used were such that the syllables appeared at intervals of 0.731, 0.615 and 0.572 seconds, respectively, depending upon the rate at which the drum was revolving, and the syllables were visible 0.609, 0.513 and 0.477 seconds, respectively. The intervals were thus so short that no time was given for a second perception or for the formation of mnemonic aids. As we have already stated, the material used by Ebbinghaus was far from being homogeneous, and had he not

[4] "Experimentelle Beiträge zur Untersuchung des Gedächtnisses," *Zeitsch. für Psych.*, 1894, Vol. 6, pp. 81, 257.

read his syllables at so rapid a rate, many of them would have been highly undesirable, due to the ease with which associations could be formed. Müller and Schumann invented a convenient plan for constructing nonsense syllables of a more homogeneous sort than those used by Ebbinghaus. Ebbinghaus left the make-up of the syllables wholly to chance, while Müller and Schumann laid down certain rules, making the series of syllables "normal" or "extra normal." A "normal" list of syllables had all the initial consonants, all middle vowels, and all final consonants different, respectively, from the syllable immediately preceding or following. The initial consonant of the first, and final consonant of the second syllable in any one of the trochaic feet into which the series was divided for the process of learning were never the same. Syllables forming well known words were never allowed to come together. A series of syllables was called "extra normal" when no two syllables used on the same day had two letters the same.

The most important results of Müller and Schumann's experiments bearing on the quickness of learning may be stated as follows:

1. The association between syllables of the same measure is much stronger than that between adjacent members of different series. The suppression of rhythm in memorizing lists of nonsense syllables renders the task much more difficult,—nearly twice as much time being required.

2. The syllables first learned are not necessarily those presented the earliest. Frequently those syllables at the end of the set are the first the subject is able to reproduce. The syllable first learned is that which first attracts the attention strongly. This may be because certain associations arose easily, or it may depend on circumstances purely accidental, *i. e.*, the syllable may have appeared just when the attention was at its "height," and thus the syllable having *gained* the "ascendency," *kept* it, since the attention naturally centered on it every time.

3. The first of any two successively and simultaneously experienced syllables tends to call up the second. If they are

associated only through intermediate syllables, the association is stronger if both are accented. The second syllable of a trochaic measure tends to call up the first, and this tendency seems to be stronger than the tendency to call up the first syllable of the next succeeding foot.[5]

4. Under certain conditions, syllables with associations already established prove *more* difficult to memorize in combination with new syllables than when such associations are lacking. The previous associations press in on consciousness and disturb attention in various ways.

5. The ease of memorizing seems to depend upon the *amount* and *character* of the word that has immediately preceded, aside from the factor of fatigue, which, of course, is all-important.

6. The ease with which such a series of syllables is learned depends not alone on the subjective differences, but on objective conditions as well. These latter, however, may *lead* to subjective differences.

Colegrove, in his book entitled "Memory," briefly sums up other results of Müller and Schumann's work, as follows: A syllable series can be learned more easily (1) if two or more succesive syllables have like initial consonants; (2) if two syllables rhyme; (3) if two successive syllables or initial syllables of two successive rhythms have the same vowel or diphthong; (4) if the beginning consonant of the first syllable and the end consonant of the second syllable of a rhythm or the end consonant of a syllable and the beginning consonant of the next syllable are the same; (5) if two or more syllables form a word. On the other hand, consonants difficult to pronounce or an accumulation of diphthongs impede the act of memorizing. A series in the trochaic rhythm is memorized more easily than a series in the iambic rhythm.

As regards retention, Müller and Schumann found that the person who memorized a series of nonsense syllables in the shortest time also relearned it after twenty-four hours in the shortest time. This was to be expected, since what is forgot-

[5] We should not, however, infer from this that every presentation *always* tends to call up the one *preceding*, but we should take it, that when any element of a complex presentation is supplied it tends to call up all the others.

ten will be relearned more quickly by a quick learner than a slow learner will relearn an equal amount forgotten. They found, however, that the slow learner saved more time, both absolutely and relatively, than the fast learner when the time of relearning was compared with the time of original learning.

Whitehead, in "A Study of Visual and Aural Memory Processes,"[6] sets out to answer the following questions, among others: (1) What is the relative *quickness* of the visual and the aural senses when employed in the memorizing of nonsense syllables constructed like those of Müller and Schumann? (2) What is the relative power of *retention* for matter memorized visually compared with that memorized aurally? Or, put otherwise, what is the relative rate of forgetting for material memorized in the two ways?

Whitehead answers the above questions as follows: "(1) Of our thirteen subjects, ten showed themselves able to memorize most rapidly from visual presentations and two from auditory, while one gave ambiguous results. This outcome is without much doubt to be correlated with the fact that so much of our memorizing, whether it occurs in the verbatim form or merely as the assimilation of meaning, is brought about through *visual processes.* (2) Matter memorized aurally appears to be retained slightly *better* than that memorized visually. It requires less repetition by 32 per cent. to learn anew from visual presentations matter memorized visually a week previous, and less repetition by 40 per cent. for aural memorizing of the same kind. The difference is insignificant, in view of the total number of cases. It seems to be simply a special case illustrative of the general principle already mentioned that the greater the number of original repetitions, the less the number necessary for learning anew."

In regard to individual differences in retentiveness, Whitehead considers that the slow learner both relearns in shorter time and retains a larger amount than the fast learner. An examination of his results, however, does not entirely support this conclusion. As Pyle very correctly says, "If we eliminate the results from one of his subjects (the eleventh

[6] *Psych. Rev.*, 1896. Vol. 3, p. 258.

in the first table, p. 267) as being an error (for it shows a relearning time longer than the time for original learning) and add the relearning times for the fast six and the slow six, respectively, we find without exception that the six who had learned in the shortest time also relearned in the shortest time. In fact, if we rank the two series for learning and relearning for the various tables from the best to poorest, we find a fairly high degree of correlation between quick learning and good retention."

Jost, in his article entitled "Die Assoziationsfestigkeit in ihrer Abhängigkeit von der Verteilung der Wiederholungen,"[7] considers the problem of to what extent the distribution of repetitions influences the strength of association. We have already given a brief summary of his work in the preceding chapter (p. 69). At first he used the method of "complete memorizing"; then he used the method of "right associates," and finally the two in conjunction. By the first method he found that ten readings of a series of nonsense syllables on each of three successive days made the memorizing of the series on the fourth day *easier* than did thirty readings on the day immediately preceding, although the difference is small. By the method of right associates he found that when twenty-four repetitions were distributed equally on three, six and twelve days, respectively, the most extended distribution (that of *two repetitions* a day) gave the best retention.[8] Jost emphasizes especially the matter of repetitions, and explains the value of rests between readings by the theory that the repetition of an old association has a greater value, relatively, than the repetition of a younger one.

In her article entitled "Experimentelle Beiträge zur Lehre vom ökonomischen Lernen,"[9] Miss Lottie Steffens considers the problem of the most "economical" method of learning more especially for logical trains of thought. The two methods of study which she compares are the "piecemeal" and the

[7] *Zeitsch of Psychol.*, 1897, Vol. 14, p. 436.

[8] The question naturally arises, however, as to whether some other distribution might not be still more favorable. This problem, viz., the *optimum distribution of time* has been considered in greater detail in Chapter III.

[9] *Zeitsch.*, 1900, Vol. 22, pages 321, 465.

"entire" (or "mass") method. The former is that usually adopted spontaneously by a person who has a long passage to learn, and consists in dividing the passage into parts and reading each part separately till it can be recited, finishing up possibly by a few readings of the whole passage. The "entire" method, on the other hand, consists in reading the passage as a whole through and through until it is learned. The "entire" method, though not appealing to the subject at the outset, is shown experimentally to be the more economical as well as resulting in better retention.

Steffens's experiments were repeated by Pentschew[10] with both children and adults. He confirmed the advantage, for adults, of the "entire" over the "piecemeal" method of study, and also for children so far as concerns the learning and retention of *meaningful* material. With nonsense syllables, however, children did better by the "piecemeal" method. This was probably because, with children, the learning of material that carries no sense demands so much effort that considerable disinclination and fatigue creep in unless the syllables are studied in small groups.

Ogden, in his paper entitled "Uber den Einfluss der Geschwindigkeit des lauten Lesens auf das Erlernen und Behalten von sinnlosen und sinnvollen Stoffen,"[11] obtains results much the same as those of Müller and Schumann. He finds that the fast learner usually requires less time for his relearning than does the slow learner. Ogden used both *logical* as well as *nonsense* material, and the results obtained were in each case practically the same. He found that although the curve of relearning is, as a rule, nearly parallel to the curve of initial learning, it shows, as a rule, some flattening—thus tending to show that individual differences in time of re-learning are not as great as are the differences in time of initial learning.

Henderson[12] found that, in general, those who learn quickly are able later to recall a greater percentage of what they have

[10] "Untersuchungen zur Ökonomie und Technik des Lernens." *Arch. f. d. ges. Psychol.*, 1903, Vol. I, p. 417.

[11] *Archiv. f. d. ges. Psychol.*, Vol. II, p. 93.

[12] E. N. Henderson. "*A Study in Memory*," *Psych. Rev. Mon. Sup.*, Nov. 23, 1903.

learned than are the slow learners. In other words, he finds that the power to learn readily correlates with the power to remember what has been learned. In his experiments, however, he did not allow his subjects to completely learn the material used and this was limited to prose. Moreover, the only material he used was prose. Briefly, his method was as follows: He requested his subjects to read twice a selection taken from Irving's "The Dutch Homestead." For this procedure three minutes were allowed. The subjects were then requested to write down as much as they could remember. Two days later they were again called upon to write down as much as possible, and after a lapse of four weeks a third recall was demanded. His subjects varied from ten years up. Henderson found that the older subjects learned somewhat better than the younger, and explained this as due to their greater capacity to understand. This capacity, however, seemed to have no influence on the relative retention. As already stated, Henderson confined himself to prose, and his results should not be held to apply to nonsense syllables or other meaningless material. Even with respect to prose, which was the material he used, his results cannot be directly compared with those of experiments in which *complete* memorizing has occurred.

Radosavljevich,[13] conducting experiments in Meumann's laboratory upon both adults and children, found, as did Ebbinghaus, that meaningful material was better retained than nonsense material. He also confirmed Ebbinghaus's statement that long series of nonsense syllables were relatively better retained than short series when each had been studied to the point of correct recitation. He found practice to increase both the speed of the first-learning and of re-learning, but the former more than the latter, indicating that memorizing and retention were probably two distinct factors of memory, possessing their own peculiar laws and conditions. The slower learners showed a greater "saving" in relearning, and Radosavljevich concluded from this that the slow learners retain better than the rapid learners. Adults learn more rapidly than children, but (according to the "saving" method

[13]"Das Behalten und Vergessen bei Kindern und Erwachsenen nach experimentellen Untersuchungen," Leipzig, 1907.

he used) retain less of what they have learned; and the younger children, similarly, learn more slowly, but retain better than older children.

Extensive experiments upon "The Relation of Facility of Learning to Tenacity of Impression" have been conducted by Miss Gamble since 1908, and are not yet published in full at the date of this writing.[14] Her experiments were designed to answer the following questions:

1. Do the persons who learn with the greater degree of facility retain for a given time the larger fraction of the material severally mastered?

2. In the case of individual subjects, does the rate at which material is presented affect the fraction of the initial learning time which is saved in the relearning?

3. When the learning time is lengthened by the difficulty of the material, is the relearning time relatively short or relatively long?

4. How may retention best be gauged?

Two sets of experiments were made. The first set bore only upon the first and fourth of the above questions, and was made by the *method of retained members*.[15] The other set, made by the method of complete memorizing (Erlernungsmethode),[16] bore upon all four questions.

In the first set of experiments Gamble used as subjects 350 college students, and as material words, letters and figures. The method of presenting the material and the method of ascertaining each subject's degree of retentiveness differed somewhat from year to year, but the procedure may be roughly outlined as follows: The material was read four or five times to the subjects, and five or six weeks later was again presented. The subject's tenacity was gauged by the two methods: The first was comparable to what I have called "Method

[14] The rather brief summary of her work here given has been made from notes taken during the reading of a paper by her at the Washington meeting of the American Association for the Advancement of Science (Dec., 1911).

[15] This method consists in measuring how much of a list of syllables, or other material can be correctly reproduced after a given number of repetitions.

[16] This method will be found described on page 78. As used by Gamble, it was practically the same as the method used by Ebbinghaus, except that with her the presentations were aural instead of visual.

1,"[17] retention being gauged by the amount of material that could be reproduced without a fresh presentation. The material was then read once to the subjects, after which another reproduction was called for. This is practically the same as what I have called "Method 2,"[18] .The material was then read several times to the subjects, after which still another reproduction was called for. In some respects, as far as results go, this is very much the same as my "Method 3,"[19] although *complete* relearning was not allowed. On the basis of the results obtained by Method 1, the subjects were arranged in two scales, according to their facility in learning and according to their retentiveness as measured by the fraction retained of the amount originally learned. Each scale was divided into quarters. Gamble found that those who fell in the first quartile as regards facility in learning fell in the first quartile as regards retentiveness in sufficient numbers to show a marked correlation between quickness of learning and tenacity of impression.[20] She recognizes the fact that some subjects who learn a very small amount in the first experiment appear to have retained a relatively large amount, merely because the amount learned the first time was so small that almost anything retained must be a large fraction of it. The results secured by what I have called "Method 2" were of doubtful significance, but the results obtained by "Method 3" showed, as might be expected, a marked correlation between facility in learning and relearning.

In the second set of experiments mentioned above (those made upon subjects by the method of complete memorizing) facility and tenacity were gauged by the time (in seconds) of learning and relearning. The material consisted of nonsense syllables. The time which elapsed between learning and relearning was either one or two weeks, differing with different subjects. In these experiments Gamble found a slight cor-

[17] See below, page 98.
[18] See below, page 99.
[19] See below, page 99.
[20] Were there no correlation whatsoever it is obvious that, by chance alone, about 25 per cent. of those standing in the first quartile of "primary learning" would stand in the first quartile of "retentiveness." As a matter of fact, however, Gamble found that the percentage was about 45.—*i. e.*, 20 per cent. more than chance alone could account for.

relation between quickness of learning and retentiveness. This, however, she found by what we might term the "absolute" method of comparison, viz., a comparison of the actual time taken for relearning with the actual time taken for the original learning—not dividing the one into the other, and, therefore, not a comparison of percentages. Gamble thus found that when facility and tenacity are measured on an absolute time basis those who learn quickly are apt to relearn quickly.

Gamble found that when a series of nonsense syllables was learned and relearned at the same rate of presentation the fraction of the learning time saved in relearning is greater if the presentation rate is neither very slow nor very fast. When the series are learned at different presentation rates, but relearned at the same rate, the fraction of the learning time saved is greater for the series which were originally learned at the slow rate of presentation unless the absolute learning time of the "slow series" is very small. Series which are hard to learn are more often hard than easy to relearn.

In attempting to answer the question how retention may best be gauged, Gamble admits that no single method is satisfactory. She objects to a method of reproduction without fresh presentation, for the reason that if a long time has elapsed since the series was learned, very many of the subjects can actually reproduce no units whatsoever, although the series may have left subliminal impressions which differ from subject to subject. Although she thinks the method of relearning is valuable to use in conjunction with others, she points out the impossibility of distinguishing the revival of old impressions from a genuine new learning. In the paper here summarized she reached no definite conclusions in regard to the best method of testing retentiveness.

Pyle, in studying "Retention as Related to Repetition,"[21] used for material passages from an elementary book on nature study, containing 40 "ideas" each. Each passage contained on an average 150 words. The subjects taking part in the experiment were twelve graduate and senior college students.

[21] *Jour. of Ed. Psych.*, 1911, Vol. II, page 311.

Pyle's method of presenting the material to the subjects was as follows:

The experimenter read the material to the subject. After the first reading the subject gave orally as many ideas as he could recall. The experimenter checked up the report, recording the number of ideas correctly reported. Then the material was read a second time, and a second report was given by the subject and checked up by the experimenter. The experiment was continued in this manner until the subject reported, in his own words, every idea. [The experimenter, having before him a copy of the material divided off by vertical lines into forty units, found it easy to check up the reports as given orally.]

After the lapse of twenty-four hours the subjects were called upon to reproduce, in writing, as much of the material as possible. The written "ideas" were marked either "right" or "wrong,"—"ideas" that were partially correct—that is, that had a "kernel" of truth, being marked as correct if they closely approximated the correct idea; rarely, half-credit was given when the variation from the correct meaning was considerable. The material was divided into such small units—each *significant* adjective, adverb or expression being set off as a separate unit—that this point gave little trouble—a subject either reported the idea or he did not.

It will be noted that Pyle used only one interval of time. i. e., he allowed but one interval to elapse between the time of learning and the time of attempted reproduction, namely twenty-four hours. That only one interval of time was used is not, of course, a criticism against the experiments he performed, but it naturally limits the extent of the generalizations he is entitled to deduce from the results obtained. It should be said, however, that with two subjects half the material was checked up thirty days later. Notwithstanding that the two subjects chosen were extremes (i. e., one a fast learner and one a slow learner), the amount retained at the end of the thirty days' interval was no larger with the slow learner than with the fast learner. Pyle also tested the retention of the members of several classes one month after the first memorizing, and found the chances to be at least three out of

four that students would maintain the same rank in long retention that they had in immediate reproduction.

The result of Pyle's most extensive set of experiments are shown in the table below. Only four subjects were used, but each of these memorized 21 passages (of 40 "ideas" each).

Subject.	Repetitions Necessary to Learn.	Av. Dev.	Retention (No. of Ideas).	Av. Dev.
C	4.7	2.24	37.5	2.0
F	2.9	0.78	38.5	1.7
K	5.2	1.40	34.2	4.6
J	3.6	1.90	36.7	3.2
Ave.	4.1		36.7	

The results as given in this table show no great difference in amount retained between the fast learners and the slow learners. What little difference there is would seem to be in favor of the fast learners. It will be noted, however, that we can only say that they retain more *absolutely*. It is possible that had Pyle allowed his subjects to relearn the material previously memorized—obtaining his "amount retained" by dividing the time of second learning by the time of first learning—he might have found that the slow learners, although remembering absolutely less, could *relearn* what they had forgotten in a smaller percentage of their original learning-time than would be required by the fast learners.

By the absolute method, however, Pyle is probably correct in his conclusion that "the slow learner certainly has no advantage in retention over the fast learner." It should be understood, however, that no general conclusions can be drawn from so few subjects, and although in general Pyle's eight other subjects bear out the same conclusion, they do not do so unanimously. His later study,[22] however, of 600 school children shows a high correlation of learning capacity, as measured by immediate memory, with retention, as determined by amount retained five weeks later. This extensive study confirms his earlier intensive study, and his conclusions may be stated as follows: A slow learner, i. e., one using a relatively large amount of time, or a great number of repetitions, does not retain more absolutely than the faster learner who uses less time and fewer repetitions.

[22] *Jour. of Ed. Psych.*, 1913, Vol. IV, page 61.

In 1911 Busemann, in an article entitled "Lernen und Behalten,"[23] published results of several years' work on various aspects of the memory problem. Only a small portion of this work, however, throws light on the relation of quickness of learning to retentiveness. His experiments were performed on school children ranging in age from 12 to 18 years. As material he used lists of various parts of speech (nouns, adjectives, etc.) and simple syllables. From his results he concludes that of two individuals, the one who takes the greater amount of time in memorizing a series of words will require less time, relatively, in relearning them.

In performing his experiments Busemann used two methods—the method of *complete memorization* (Ersparnisverfahren) and the *method of right associates* (Treffermethode). He does not feel that his experiments with the first method can answer the question as to whether the quick learner also forgets quickly. He considers the "Treffermethode" the one to use in answering this question, but does not feel that with this method he performed a sufficient number of experiments to warrant his making any general statement. His results, however, as far as they go, would seem to point against the assumption that it is the quick learners who forget quickly. In summing up his work on this subject he says, "It has not yet been proven that a greater ability to learn corresponds to a smaller ability to retain; on the contrary, it is probably true that the good learner is at the same time a good retainer."

Miss Norsworthy, in an article entitled "Acquisition as Related to Retention,"[24] presents some very interesting results. As subjects she used 83 students in educational psychology. The material used, as well as the method of experimentation, were different from any that we have thus far discussed. It consisted of a German-English vocabulary of 1200 words. Each student studied twenty minutes for five days, memorizing as many of the English equivalents of the German words as possible. Two days were then allowed to elapse, when each student reviewed the list of words that he had succeeded in "memorizing" during the previous five

[23] *Zeit. fur angewandte Psych.*, 1911, Vol. V, page. 211.
[24] *Jour. of Ed. Psych.*, 1912, Vol. III, page 214.

days. Two days more were then allowed to elapse, and the work was again reviewed. At the first meeting of the class after the above three study periods were over they were asked to write the English equivalents of a certain 50 German words that were presented to them,—words which had occurred in the list of German words they had succeeded in previously memorizing. From the results the percentage remembered could then be ascertained. One month after this test another list of 50 words, chosen from those that remained, was presented to the subject with the request, as before, to write down as many of the English equivalents as possible. In like manner the percentage remembered of these 50 German words was ascertained.

Norsworthy found that the *average* per cent. remembered in the first test was 63, and that the *average* per cent. remembered in the second test, one month later, was practically the same, being 62. From these averages she found the deviation (either plus or minus) for each of her 83 subjects. The average deviation from the median for the six subjects learning 700 words or over was + 14, whereas for the 13 subjects who learned only 300 words or under the average deviation from the median was — 17. In other words, the quickest learners, who had mastered a vocabulary of over 700 words in a fixed time, retained a larger fraction than the slowest learners were able to retain of their much smaller vocabulary, learned in the same time. With the second test the difference was even more striking. The upper half of the class, in respect to size of vocabulary learned, remembered in the first test on the average 70 per cent., the lower half only 52 per cent. The Pearson coefficient for the whole class between the number of words learned and the average per cent. remembered is .41 for the first test and .50 for the second test. In short, Norsworthy finds a high positive correlation between rate of learning and retention—a correlation that is considerably higher than that obtained by any of the investigators whose work we have already examined. This, however, is probably due not only to the method she used—the time remaining constant, but the amount learned varying—but also to the nature of her material. This is not meant as a criticism. In fact, it is prob-

able that the use of such material as a German-English vocabulary, especially when used in the manner chosen by Norsworthy, is far better than the use of such material as nonsense syllables, if we are to mean by "memory" such memory as occurs in everyday life and especially such as occurs in the schoolroom.

Norsworthy's method of keeping the time constant, but allowing the amount learned to vary has numerous advantages. It frees the learner from the responsibility of having to decide when he thinks that the material has been thoroughly memorized—"a responsibility that brings a very varying personal equation into the problem. It also frees the investigator from the burden of making a fair allowance for imperfectly-learned material."[25]

* * * * * * *

In summing up the results of these various investigators it is perhaps fair to say that they have found, *in the main,* and other things being equal, the individuals who learn the quickest to remember the longest, *i. e.,* to be the best retainers.

Müller and Schumann found that the quick learners forgot more, but were able to relearn what they had forgotten in a shorter time than the slow learners. An examination of their data shows that, *relatively* speaking, there is not much difference between the quick and the slow learner. Whitehead believes that the slow learner is a better retainer, but from the data he gives it is difficult to see just how he arrives at this conclusion. Norsworthy, on the other hand, obtains a very high positive correlation. Working with a German-English vocabulary, she finds that the last quarter of her class retain only two-thirds as much as the first quarter. Ogden and Henderson, working with meaningful material, unite in finding that, as a rule, the quickest learner is the best retainer. Pyle is somewhat more conservative, but says that the fast learner is certainly at no disadvantage in retention.

With most of his subjects Busemann finds that rapid learning means good retention. Gamble, dividing her classes into halves, quarters, etc., after much the same manner as Norsworthy, obtained also a positive correlation.

[25] *Op. cit.*

In the following pages an attempt will be made to prove that on the problem in question no general law or conclusion can be drawn from the use of any single material or method. We shall endeavor to prove that not only do different methods give different results, but we shall endeavor to show that *with the same data* it is possible to draw contrary conclusions by dealing with this data in different ways.

METHODS EMPLOYED.

THE PROBLEM STATED.

The experiments, which, with their results and the various methods of dealing with same it is the special object of this chapter to discuss, may be briefly stated as consisting in the learning, or "memorizing," of certain materials, allowing a definite number of days to elapse, and then measuring retention by one or more of the methods later to be described. In this way an approximate idea was obtained of each subject's *retentiveness,* and by comparing this with his *time taken for the initial learning* a fairly accurate idea of the relation of his quickness of learning to his retentiveness was obtained.

So varied were the materials used, and so different the ages, conditions, intellectual standing, etc., of the subjects experimented on, that many results were obtained that have been considered sufficiently valuable to warrant mention, although they have no direct relation to the problem of relation of quickness of learning to retentiveness. Besides the so called "normal" subjects, State prison convicts, and asylum patients were tested. The latter, over 200 in number, give results so complex in character that they will be considered only very briefly.

The data obtained show not only the relation between quickness of learning and retentiveness, but also (1) the relative amount of forgetting after different intervals; (2) the relation between memory for logical trains of thought and that for lists of syllables and digits; (3) the effect of age, sex, and training on rapidity of learning and remembering; and (4) a comparison of the amount actually retained by each subject (after an interval of one week) with that which he can reproduce after one reading of the material is allowed.

METHODS OF EXPERIMENT.

The main difficulty that one encounters in investigating such a problem as the one in question is to determine which of the various possible methods and possible materials shall be used. To use all methods and all materials would involve too great a labor for any one experimenter. Three methods were used in this research. Since each method is frequently spoken of and referred to, it was deemed best to give each one some distinctive appellation, and I have named them "Method 1," "Method 2" and "Method 3." Briefly stated, these methods are as follows:

Method 1. Reproduction, as far as possible, of the material originally learned without fresh presentation.

Method 2. Reproduction, as far as possible, after a single presentation.

Method 3. Supplying the subject with the original material and taking his time for relearning it.

We shall now consider each of these methods in detail.

Method 1.—The subject was given, face downward, a sheet of paper on which were typewritten 20 nonsense syllables.[26] He was told that he could study these in any way he saw fit, but that as soon as he felt positive he could repeat them without error he should say "now" and come to the experimenter's desk. He was advised not to come up before he felt quite certain that he could repeat them without error, as the time consumed, if he failed to give a perfect reproduction, would be counted as part of his "time for learning." To avoid competition, each subject was taken separately, although where the opportunity presented itself several subjects were allowed to study in one room and allowed to come to the adjoining room for their hearing. Instead of reciting his work, each subject was allowed, if he preferred to, write out his reproduction at the experimenter's desk.

The question will naturally arise: What was done when

[26] In explaining these three methods we shall speak only of nonsense syllables.

the subject came up for examination and made numerous mistakes? To this we can only say that such was seldom the case, it being thoroughly impressed on the subject's mind that he must be sure he could repeat the material perfectly before coming up for his recitation. Where several serious mistakes were made, the subject was sent back to continue his work of memorizing; but where there were only one or two minor errors, it was thought best to deduct for these in as fair and scientific a way as possible rather than send the subject back. This may not seem strictly accurate and scientific, but of two evils it was thought to be the lesser.*

The material having thus been learned, a definite time interval[27] was allowed to elapse, after which each subject was called upon to reproduce, in writing, as much of the material as possible. It is in this reproduction, without fresh presentation, that we have "Method 1." No especial directions were given for "Method 1," other than requesting that each subject write down as much of the original material as he could remember, using the original words whenever he was able. He was also told, when logical matter was the material used, that where he could remember nothing but the "gist" of the passage,[28] to "put that down as best possible."

Method 2.—Method 2 was made to follow immediately upon Method 1. The directions read to the subjects for this method were as follows:

"You have just tried to reproduce from memory a set of 20 nonsense syllables that you learned one week ago. You probably have a fair idea as to the correctness of your paper. I shall now read to you the original set of nonsense syllables, after which you are to again write out the list so far as you are able."

This method, which I have designated as "Method 2," is, to my mind, one of the most satisfactory.

Method 3.—Method 3 was made to follow immediately on

*It frequently happened, for example, that a subject whose average time for twelve nonsense syllables was 15 minutes, might, if sent back to correct a single error or omission, study 10 or 12 minutes *more* before he again came up for examination—thus nearly doubling his normal time.

[27] This varied in the different experiments from 1 day to 10 weeks.

[28] We are here supposing the material was prose or poetry.

Method 2. The directions read to the subjects for this method were as follows:

"You have tried to reproduce, in writing, after one hearing, a set of 20 nonsense syllables that you memorized one week ago, and you undoubtedly have a fair idea as to the correctness of the paper you have just handed me. I shall now supply you with the original set of nonsense syllables, with the request that you *re*learn them, saying 'now' when you feel certain that you can reproduce the entire set."

Due to the fact that in Method 2 the original material is read to the subject, he does not enter upon Method 3 with as much ignorance of the material as would be the case if "Method 2" were omitted. In view of this, in some of the latter experiments a separate series of syllables (or other material) was used for "Method 3." This necessitated the memorizing, in the first place, of two distinct sets of syllables—one for Methods 1 and 2 and another for Method 3.

The writer is aware that these methods are open to criticism. In the first place, no one of the three methods alone is sufficient to answer the problem, and in averaging their results it is a question which method to give the most weight to. At the outset of the experiments Method 3 was ranked most *apropos* for the problem in hand, and therefore graded as the most important. *Method 2* was ranked next. Later, however, it was thought best to count each method as equal, for the reason that recall without fresh presentation is the form most often demanded in daily life, and retentiveness *in general* was more the factor to be considered rather than any special form.

We shall now, taking one method at a time, consider the chief criticims that may be raised against it.

Method 1 has the advantage of getting directly at the matter in hand, *i. e.*, of obtaining from each subject exactly what has been so well retained that it can be voluntarily reproduced after a lapse of a certain period. It has, however, several disadvantages. The chief of these is that reproduction, without a fresh presentation of the material originally learned, reveals only the strongest of the original impressions—the so-called "supraliminal associations." It can be proved that many of the subjects have a considerable portion of the material

once memorized on the "borderland," so to speak—material that can be entirely recalled after one further reading. Were our investigation merely one dealing with the question of the relation of quickness of learning to *reproductiveness,* we would have to rank Method 1 higher than any other; but where ability to *retain* rather than ability to *reproduce* is the factor in question, it is obvious that we must take into consideration the various associations that are on the "borderland."

Method 1 also has the disadvantage of giving results that are difficult of measurement. Very frequently, in an attempted reproduction of material once memorized, the subject (if he is able to recall the various "topics" and "subtopics" and the "thought" of the passage in general) is apt to express this "thought" in a greater number of words than existed in the original passage. He is also very apt to introduce new thoughts—thoughts which he may or may not express in words that occurred in the original passage. This introduces several complex factors and make an accurate measurement difficult.

Method 2.—Its chief merit lies in the fact that it endeavors to do away with the criticisms made above against Method 1. To this end it endeavors to bring back the "subliminal" associations by reading the material once to the subject before asking for a reproduction. This one "reading," however, carries with it its own penalty. A single reading of a passage of 100 words consumes about one-half minute, and it is obvious that one-half minute to a quick learner means much more than does one-half minute to a slow learner.

The second objection made to Method 1 naturally applies also to Method 2, although not to so great a degree, for this reproduction after hearing the passage read is less likely to contain new thoughts and extra words than if the passage had not been read at all.

Method 3.—In the following pages "Method 3" has received more attention than either "Method 1" or "Method 2." Its chief advantage lies in the fact that it supplies us with an easy and accurate form of measurement. It is a question, however, if it is a fair method to use in settling the problem in hand, in that it introduces the factor of "relearning." In utilizing the

results of this method the plan of Ebbinghaus was followed, the time for relearning being compared with the time of the original learning. The time thus saved (especially the *per cent.* of the original time saved) is taken as the measure of retention, while the time spent in relearning (expressed as a per cent.* of the time of the original learning) gave the complementary measure of the "amount forgotten."

The chief disadvantage to this method is that, in relearning, it is impossible to distinguish facility in forming fresh associations from retention of subliminal associations. Another disadvantage is that it does not get directly at the amount and nature of the matter retained by each subject. It is thus a serious question if the method is a fair one to use in settling the question in hand, for with this method the subject is not called upon to give exactly "*what he remembers*" at the end of three weeks, but is first given the material to relearn, and *then* asked for a reproduction. A factor is thus introduced that is difficult of measurement, for this "relearning" may recall more to the mind of one subject than another, both of whom might otherwise have given equal results by the first method. It may, however, be justly contended that this factor is desirable, since our problem is one dealing with *retentiveness,* rather than ability to recall.

Another criticism that may be made against Method 3 is this: It may be said that it is incorrect to rate two men as having the same degree of retentiveness, one of whom takes 25 minutes to learn a passage and three weeks later takes 5 minutes, while the other takes 10 minutes and three weeks later takes only 2 minutes. It may be true that these figures prove both men to have saved four-fifths of the time originally spent, and that, therefore, the amount of the original that each has forgotten is one-fifth; but this hardly seems fair, when we consider that the second man takes *only* 2 minutes to do his relearning as against the 5 minutes needed by the first man. There is still another to be considered in favor of the second man:—it is possible that the first man had forgotten

*This *percentage* is not given (directly) in the following tables, though it may be computed. It is given directly, however, in the sample tables given in Appendix C.

the material so completely at the end of three weeks that not only was he unable to recall any of it, but he also retained practically none of it, and that the second learning was for him practically a memorizing of entirely new material, and that *this* time he took only 5 minutes, because he was in exceptionally good condition. In fact, when the material used consists of digits we would expect the time for relearning to be, on the average, nearly as great as the original time.[29]

However, taking everything into consideration, Method 3 has many merits, and gives us information that neither Method 1 nor Method 2 is capable of. It also has the advantage of supplying us with a very easy and accurate measurement, namely, time.

One objection carried by Method 3 is that it makes no allowance for the partial relearning that the preceding Methods (1 and 2) have given. Method 3 is supposed to show,[30] besides other things, the actual time that is taken for relearning the material. It is obvious, therefore,* that before starting this method the subject should not only not have thought of the material during the period that has elapsed from the day it was originally learned, but he should not be allowed to "review" it just previous to starting Method 3. It is just these things, however, that Methods 1 and 2 do, for in the one the subject endeavors to recall as much of the material as possible, while in the other he is allowed a "review." This, however, is not a criticism against Method 3, *per se,* but a criticism against the way in which the method was here used. Rectification was made in two ways—(1) either a separate and distinct material was used for Method 3 or (2) the time taken for the reading of the passage (in Method 2) was added to the time given in column 3. [In some cases the time taken for the "attempted reproduction" was also added.] It will be noted, however, in those tables where this has been done that the addition of a minute or two throughout column 3 makes practically no difference in the final correlation.

[29] In several cases the second time was not only equal, but even greater. This is ascribable either to a poorer mental condition of the subject or to distraction of some sort.

[30] See column 3 of any of the tables.

* *i. e.,* if we desire Method 3 *alone* and in its purest form.

One criticism that might be made of all the methods rather than of any one method in particular is that an investigation of this subject, to be thorough, should involve the use of various time intervals. For example, instead of merely allowing 10 weeks to elapse between the time of *initial learning* and time of *relearning* we should also use intervals of one day, one week, six months, etc. Proof that the length of the time interval allowed to elapse should be seriously considered is seen in the fact that with most groups of subjects the correlation of quickness of learning with retentiveness depends to a certain extent on the length of the time interval.

The complete solution of a problem of this nature should take into consideration all the mental performances of the subject. It should involve the use of all the senses, since each one, as was explained in Chapter I, may be said to have its own "memories." Limited experiments, such as these here described, can answer the question only in a limited degree.

MATERIALS USED.

Five main kinds of material were employed on all of the regular subjects. [In the case of the insane, some of these were omitted or abbreviated.] These five materials were digits, nonsense syllables, words, prose and poetry. Of each of these four sets were employed. The specifications of each of the materials chosen, with the method by which it was selected, are given below under their respective headings:

(*a*) *Digits.*—In the regular set of experiments the number of digits used was 20. With one group of 16 individuals series of 40 were also used. The method of procedure in making the list of digits was as follows:

Small cards, bearing the digits from 0 to 9, inclusive, were placed in a box and shaken up. They were then taken out, one at a time, and if the digit drawn violated none of the rules given below, it was written down as one of the list. In any case, before drawing another digit the digit previously drawn was put back in the box and the box shaken.

Rules:

1. The digits must be drawn by chance.
2. No digit may be allowed to follow another that is one-

half as much or twice as much as the first, *e. g.*, 6 may not follow 3 nor 3 follow 6.

3. No digit may follow another that is only one more or one less than the digit in question, *e. g.*, 4 may not follow 3 nor 3 follow 4.

4. No three digits may be allowed to come together that have the same difference between them, *e. g.*, 3-5-7.

5. No two digits may come together that have already appeared together in the list.

6. Since digits, like nonsense syllables, words, etc., are generally learned rhythmically in groups of four, no digit may start a group that had previously been used to start a similar group, nor may the final digit of a group (of four) be permitted to stand if it has already been the final digit of a preceding group (of four), *e. g.*, if 7-1-5-2 have occurred once as one group, no other group in the same series may start with 7 or end with 2.

(*b*) *Nonsense Syllables.*—The diverse results that have been obtained by different experimenters using nonsense syllables as material can be partly explained by the difference in the syllables selected, i. e., differences in their degree of "nonsensity." In many cases the nonsense syllables employed by Ebbinghaus belie their name and are not nonsense syllables in the strict sense of the word. Even for the German language many of them are in German as practically words. Those used by Müller and Schumann were selected with greater care, and are, on the whole, much better. A really good set of nonsense syllables is extremely difficult of formation. My own method of making the series of 12 and 20 was as follows:

Out of a list of 90 nonsense syllables,[31] three competent judges selected forty-five that, to their minds, "carried the fewest objections." These forty-five were then placed in a box, and, by following the rules given below, three sets of twenty were selected. Here, as with the digits, if the syllable drawn violated any of the rules, it was thrown back and another selected in its place.

[31] There are only about 90 fairly good nonsense syllables for English-speaking persons.

The rules observed in the arrangement of the nonsense syllables were as follows:

1. Syllables must be drawn by chance.
2. Initial consonants may not be the same unless separated by two or more syllables.
3. End consonants may not be the same unless separated by two or more syllables.
4. Vowels may not be the same unless separated by two or more syllables.
5. The initial consonant of one syllable may not be the same as the final consonant of the preceding syllable.
6. There may be no repetition of the same syllable in any one series.

(*c*) *Words.*—In the regular experiments only nouns were used. These were drawn by chance from 200, previously selected, and arranged in lists of 20. Whenever the word drawn made, with the preceding word, an association that was considered "quite obvious" by two of the three judges, the word was thrown back. Of the four sets of words used, two were formed entirely of words of three letters.

(*d*) *Prose.*—Several passages of different nature and content were chosen.

1. A passage of 100 words from Kipling's "Kim," starting with "The diamond bright dawn."
2. A passage of 100 words from the preface of Haeckel's "Riddle of the Universe," starting with "The present study."
3. A passage of 100 words from Kant's "Critique," beginning with "Time is nothing but the form of the internal sense."
4. A passage of 100 words from Franklin's "Autobiography," beginning with "But I soon found."
5. Two sets of unconnected sentences, each set comprising in all 100 words.

(*e*) *Poetry.*—Two selections, each containing four stanzas of four lines.

METHODS OF SCORING.

The method of scoring the various reproductions of the material memorized—a matter of prime importance in an investigation of this nature—will now be considered in detail.

(*a*) *Digits.*—Method 3 needs no comment as to scoring. It is obvious that where complete relearning is used the only measurement we have to consider is that of time. With methods 1 and 2, however (where the reproductions are never perfect), mistakes are more or less numerous, and these have to be taken into consideration, be they mistakes of omission, insertion of wrong material, wrong order, or what not. In my earliest experiments I used the method devised by Ebbinghaus,[32] scoring every ommission as one error, every displacement from the correct position in the series by two or three places as 0.5 error, and every displacement by four or more places as one error. The subjects were then compared with respect to their error-score in series of each length separately. I found, however, upon correlating the scores thus obtained that my results were practically the same as when using the much simpler method used by Dr. Whitley.[33] "The chief difficulty," says Whitley, "in comparing people's work on memory lies in the variable methods of scoring, especially with regard to transpositions. If the order is 76431528 and a subject writes 7463...., some experimenters call it two errors, because both the 4 and the 6 are in the wrong places; other experimenters call it one error because by making one change—by 'lifting' the 6 over the 4—it is corrected. The latter method seems preferable. Supposing a subject were to write 87643152. Eight errors would be scored by the first method, since each numeral is misplaced; by the latter method only one error is scored, since one change would set all right." Thus a misplacement is rated by Whitley practically the same as an omission. For example, a subject writing 76-31528 would, by the first method, be scored one error for omitting the 4, but two errors if he placed it

[32] H. EBBINGHAUS. "*Ueber eine neue Methode zur Prüfung geistiger Fahigkeiten in ihrer Anwendung bei Schulkindern*," in Z. P., 1907, 13, 401-457.

[33] "*Tests for Individual Differences*," *Archives of Psychol.*, 1911, *No.* 19, Page 45.

before the 6. By Whitley's method, however, he is, by counting misplacements and omissions as equal, scored only one error. This method as used by Whitley is the method that was used in scoring the results given in the following tables. Each numeral that was given correctly was scored 1, and if it was in the right place, either relative or absolute,[34] it was scored 1 more. This method may at first sight seem crude, but many were tried and the more elaborate ones were discarded.

EXAMPLES OF THE SCORING OF SERIES OF DIGITS ARE SHOWN BELOW.

Series studied.....	5 0 9 4 7 1 5 2 6 1 8 0 4 7 3 8 1 6 2 9	
Reprod. by sub. A. F...	5 0 9 4 7 . 5 3 8 0 4 7 3 6 2 9	
Score	2 2 2 2 2 . 2 1 2 2 2 2 2 2 1 2 2	Total 28
Reprod. by sub. J. M...	5 0 9 4 7 1 5 4 1 6 8 0 2 5 9 6 4 6 1 2 9	
Score	2 2 2 2 2 2 2 . 1 1 2 2 . . . . . 1 1 2 2	Total 26
Reprod. by sub. M. K...	5 0 9 4 7 1 5 2 6 1 8 0 7 . 3 8 1 6 2 9	
Score	2 2 2 2 2 2 2 2 2 2 2 2 2 2 1 . 2 2 2 2 2 2	Total 37

(*b*) *Nonsense Syllables.*—With nonsense syllables also Method 3 gives no difficulty as far as scoring is concerned, but with Methods 1 and 2 we encounter the same difficulties that confront us with digits, since omissions and misplacements are usually numerous. Here also I first tried several of the more elaborate methods, including that of Ebbinghaus, but discarded them for one of my own make. This method, while easy and quick, proved upon comparison with the results obtained by the more elaborate methods to be fully as accurate. Briefly stated, the method is as follows: Each correct letter, provided the syllable is in the *correct position*,[35] receives a score of 1, and the syllable, for being in the correct position, receives an extra score of 1. Thus a perfect syllable in the correct position receives a score of 4. A syllable correct in itself, but not correct in position, receives a score of

[34] I counted a digit to be correct as to its *relative position* provided it was preceded by the correct digit. My reasons for using the *preceding* digit instead of the *following* digit in determining correctness of position are given in the following sub-section entitled "Nonsense Syllables." If in place of a digit the subject merely drew a line thus indicating that he was aware of an omission, he was given credit for thus preserving accuracy of position for the digit following.

[35] "Correct position" here, as with digits, may mean correct *relative* position or correct *absolute* position. A syllable is in the correct relative position when it is preceded by the correct syllable, or by a syllable of which two letters are correct, provided these letters themselves be in the right order.

only 3. If the position is correct and the syllable has two of the three letters correct,[36] it is scored 3. If two of the three letters of the syllable are correct, but the *position* of the syllable itself is not correct, either relative or absolute, it receives no score at all. Therefore, unless position is correct, the separate letters do not count unless *all* are correct.[37] It must be remembered that, as before said, if a syllable is correct, but is not in the correct position, it gets 3, and only 3, counts, since each syllable that is in the correct position and also correct in itself receives a count of 4. The highest score, therefore, obtainable for a list of 20 syllables is 80. The subjects were told to draw a line under the last syllable in their reproduction if they felt sure that it *was* the last syllable. In this way the last syllable, even if it was not preceded by the correct syllable, was counted as being in the right position and given a score—e. g., a score of 4 if the syllable was entirely correct and underlined,—3 for the syllable itself and 1 extra count for being in the correct absolute position.[38]

The method of scoring is illustrated by the following example:

List of Syllables Studied	Reproduction by Subject J. M.	Scores.
VUS	VUS	4
YIF	VIF	3
MAV	JEP	3
JEP	RIL	0
VOB	BOV	2
FEG	SIR	0
WOF	WOL	3
TIB	TID	3
NUZ		
BOF		
JED		
KIB		
VEL		
ZID		
BOL		
SEF		
YAB		
KUV	Total Score.....	18
TEF		
NAD		

[36] Provided these two letters themselves are in the correct order.

[37] When, however, all three letters are written, but not in correct order, *e. g.*, the letters reversed, the syllable receives a score of 1, but if the *position* also is correct, a score of 2.

[38] The same rule was used here as in the case of the nonsense syllables and the two letters themselves had to be in the correct order.

From the rules laid down on the preceding page for the scoring of nonsense syllables there should be no difficulty in understanding the above scores, but in order to make the method quite clear we shall consider separately each of the syllables (as reproduced by subject J. R.), stating the why and wherefore of each of the scores given. *VUS* gets 4 counts, being correct in everything. *VIF* gets only 3 counts, since, although its position is correct, it starts with "V" instead of "Y." *JEP* gets 3 counts; had it been in the correct position, it would have gotten 4, since when a syllable is correct as to its letters but in the wrong position it is credited with only 3 counts—one for each letter. *RIL* receives no score at all, there being no such syllable. *BOV* receives a score of 2, for it contains all the letters that occur in *VOB,* and, moreover, is in the correct position, i. e., where *VOB* should be. *SIR* receives no score at all. It is quite likely a pure guess, and put down merely to secure correctness of position for the two following syllables. We are all the more led to believe this when we perceive that the next two syllables, *WOL* and *TID,* have, in each, two letters correct, their positions also being correct.

We have gone somewhat more into detail concerning this method of scoring than may seem necessary in a book of this sort. Our reason for this has been that nonsense syllables are one of the materials most frequently used in investigating memory problems of this nature, and unless the reproductions are scored by an exact and scientific method the inductions drawn may be quite valueless. Should the reader use this method in any experiments he may undertake, he will notice that after a few minutes' practice the scoring of "attempted reproductions" becomes a relatively simple matter.

(*c*) *Words.*—With words, Method 3 also gives no difficulty, time being the only measurement. With Methods 1 and 2, however, a method similar to that used with nonsense syllables was employed. A score of 1 was given if the position, whether relative or absolute, was correct. Here also correctness of the relative position was determined by the preceding word. An extra count was given if any two letters[39]

[39]This method of scoring is explained in detail in an article on the subject: D. O. Lyon. "A Rapid and Accurate Method of Scoring Nonsense Syllables and Words" *Am. Jour. of Psych.* Vol. XXIV, pages 525-531.

were correct, provided that the position of the word was correct. If the word was wholly correct, it received still an extra count, making a maximum of 3 counts for each word.

The scoring is illustrated by the following case:

Series of Words Studied.	Reproduction by Subject M. K.	Score.
TUB	TUB	3
PIN	HEN	2
HEN	JUG	2
BED	RAT	0
LID	TAN	0
GEM	MUG	0
BUD	CAT	2
CAR	RUG	2
MAT	PEN	2
ROD	BED	3
JUG	GUN	3
FOG		
LAD		
SOD		
PEN		
CAT		
RAG		
BOX	Total score.....	19
NET		
GUN		

This scoring may be elucidated by the following remarks: The first word, *TUB,* is given 3 counts, it having two letters correct, it also being the correct word and also being in the correct position. *HEN* is given a score of 2, it being the correct word, but not in the correct position. For like reasons *JUG* is scored 2. *RAT* receives no score at all, although it has two letters ("*AT*") that are correct (they being also in the word *CAT*). The word, however, is not in the proper position, either relative or absolute, and hence can receive no count at all. Words of this kind, therefore, receive a score of 2 or nothing for reasons given in detail under nonsense syllables. The fairness of this rule is made clear when we realize that had the word *RAT* been preceded by the word *PEN,* the chances of *RAT* having been a mere guess would be greatly lessened. *TAN* receives no count at all. To the next word, *MUG,* one is tempted to give a score of 1, since it contains the two letters *UG,* which are also contained in *JUG.*

It would have received credit for these two letters had the word been preceded by *ROD*. Not being preceded by *ROD*, it is given no count at all. That this is perfectly fair is in this particular case very conveniently shown by the appearance later on of the word *RUG*, which, although there is no such word, is given a score of 2, it being preceded by the correct word *CAT*. The two letters that are correct in this case are *R-G*, and, although separated by the wrong vowel, U, they are in the proper order. *PEN* receives a score of 2, it having two letters correct and also being the correct word itself. *BED* receives a score of 3—1 because it contains two correct letters, 1 because it is the correct word itself, and 1 because it is preceded by the correct word. In this case the "preceding" word is not wholly correct, but it contains two correct letters, and thus *BED* receives a higher scoring than it would have received had it been preceded by the word *AXE* for example. The last word, *GUN*, receives a score of 3, it being in the correct absolute position for the reason that it is underlined, this proving that the subject knew that it was the last word.

(*d*) *Prose.*—The simplest method of scoring the prose passages is to grade the papers offhand on a basis of 10 (or 100), equaling perfection. With this method, however, some examiners would not consider that "perfection" necessarily requires the use of the identical words occurring in the original, nor might they consider that it requires a perfectly correct order of these words. With a certain amount of justification, they might say that the only thing necessary to get a score of 100 would be to have a perfect reproduction of the various ideas contained in the original passage—in other words, a practically perfect impression of the "content" of the passage. This rather rough method of scoring has been used by several experimenters. I used this method for a time, but soon gave it up for the more exact method of Henderson,[40] somewhat modified.

In scoring Henderson divided his prose passages into "topics," "subtopics," "details," and words. He was thus

[40] E. N. Henderson. "A Study of Memory for Connected Trains of Thought," *Psy. Rev. Monog. Supp.*, No. 23. 1903.

able to score his papers according to the number of "ideas" and "parts of ideas" that were retained. We shall first take up his method of scoring the smallest of the subdivisions, viz., *words,* and this is best given in a quotation from Henderson himself: "The scoring of words remembered might easily become a complicated matter. Doubtless, the reproducing of certain words means far more power of memory than that of others. I have used the following system. All words of the original that were reproduced in their former contexts were scored full value. Commonplace words, particularly articles, prepositions, and conjunctions, were not scored when reproduced out of their context. On the other hand, an unusual word was regarded as remembered even though it appeared in the wrong context. Occasionally a word was evidently used because its sound was somewhat like that of one in the original. A half-credit was here given. Words that were modified to suit changes in construction, etc., were given partial credit also."

In defending his method of analyzing a passage into the various divisions mentioned, Henderson says[41]: "It must be confessed that this analysis has in it something arbitrary. To say that each of the detailed thoughts thus indicated is equal in value to every other is manifestly absurd. And this is true whether our estimate be based on relative importance to the thought in general or on relative difficulty of recall. But it must be granted that the same objection could be raised against any endeavor to compare two mental conditions quantitatively. However, as the mind of the subject traveled over the thought it was trying to reproduce it may be conceived to have rested momentarily on each of the details indicated. In general, the better memories could be expected to retain not only the easily-remembered details, but also the ones harder to recall, whereas the poorer ones would retain only the former class. In such cases the scores given cannot be challenged on the ground that the lack of equality between the units renders the ranking of the subjects arbitrary. Placing different values on the ideas or analyzing the units differently might affect the ranking in cases where the loss of certain

[41] *Op. cit.*, p. 33.

ideas is pitted against that of different ones, but seldom, I am confident, could one justify a valuation or an analysis so different from mine as to affect materially the ranking of a student. Hence the general results of my investigation are, I conceive, not dependent on the peculiarities of my scoring.

"The scores given have not been diminished because of errors. They are records only of what was retained. I have taken the ground that the erroneous idea that contains the suggestion of the true one deserves a positive rather than a negative score. It indicates a thought corresponding, however inaccurately, to the earlier one. Such ideas are given a part of the value of an accurate memory. Some individuals, it is true, leave unexpressed the hazy idea that they fear is erroneous. They might suffer by comparison with cloudier minds that failed to discover the presence of the fog. However, a mind that feels a certain idea to be inaccurate is usually able to express the part or phase of the thought that is accurate, and thus render a true account of what was in the memory."

My own method of scoring is really nothing but a modification of Henderson's. The papers were first marked on a scale of 100 by three competent judges. The average of these marks was then taken and called "Judges' Mark." The papers were then scored by Henderson's method, the score, however, being converted into a scale of 1-100. This was termed "Henderson's mark." The *arithmetical mean* of these two "marks" was then taken as the final score. It was seldom that the two methods of scoring differed by more than 3. In one or two instances the difference was as great as 5, though this difference was mostly due to the presence of an introspective postscript that had been added by the subject, and which, while it could not be considered in Henderson's method, was evidently considered by the judges. It was frequently clear that the subject had a fair idea of certain "thoughts" that he was unable to express—thoughts that were evidently not expressed in words sufficiently correct to obtain, by Henderson's method, as high a score as the judges deemed them worthy of, for in these cases the "Judges' Mark" was invariably higher than "Henderson's mark."

The result of the scoring is seen in the following examples:

SELECTION STUDIED.[42]

And gentle Ellen welcomed her
With courteous looks and mild:
Thought she "what if her heart should melt,
And all be reconciled!"

The day was scarcely like a day—
The clouds were black outright:
And many a night, with half a moon,
I've seen the church more light.

The wind was wild; against the glass
The rain did beat and bicker;
The church-tower swinging over head,
You scarce could hear the Vicar!

And then and there the mother knelt,
And audibly she cried—
Oh! may a clinging curse consume
This woman by my side!

REPRODUCTION BY SUBJECT A. F.

And gentle Ellen welcomed her,
With tender looks and mild.
Thought she, "what if her heart should melt
And all be reconciled."

The day was scarcely like a day,
The clouds were black outright
And many a night with half a moon
I've seen the church more bright.

The ——————————
——————————
The church tower swinging overhead
You scarce could hear the preacher.

And then and there the mother knelt,
and audibly she cried,
"Oh, may a clinging curse consume,
This woman by my side!"

[42]Other selections of prose and poetry, and other lists of digits, words and nonsense syllables, used as materials with some groups of subjects are reproduced in Appendix A.

The results of this method of scoring may be seen in the following examples:

PASSAGE STUDIED.

The diamond-bright dawn woke men and cows and bullocks together. Kim sat up and yawned, shook himself, and thrilled with delight. This was seeing the world in real truth, this was life as he would have it—bustling and shouting, the buckling of belts, and beating of bullocks and creaking of wheels, lighting of fires and cooking of food, and new sights at every turn of the approving eye. The morning mist swept off in a whirl of silver; the parrots shot away to some distant river in shrieking green hosts; all the well-wheels within earshot were at work.

REPRODUCTION BY SUBJECT A. F.

The diamond bright dawn woke men and cows and bullocks together. Kim awoke, sat up, yawned and shook himself. This was life as it should be, this was seeing the world in real truth. The creaking of wheels, the lowing of cattle, the clanking of chains, the ringing of bells and new sights at every turn of the approving eye. The parrots shot off to some far away river in shrieking green hosts; the——————————
and all the well wheels of industry were at work.

Score, 72.

REPRODUCTION BY SUBJECT J. M.

The diamond bright dawn woke men, and cows and bullocks all together. Kim sat up and yawned, shook himself, and thrilled with delight. This was seeing life in real truth; this was life as he would have it. The blowing of horns, the lowing of cattle, the cracking of whips, and the creaking of wheels. (There was also something about parrots flying across the river, and that everybody was at work.)

Score, 49.

REPRODUCTION BY SUBJECT M. K.

The diamond bright dawn woke men, and ——, and bullocks together. Kim awoke and sat up. "This was seeing the world in truth, this was life as he would have it." The buckling of belts, beating of bullocks and blowing of horns, the cracking of fire and cooking of food and new sights at every turn of the approving eye.

Score, 50.

(*e*) *Poetry.*—The scoring of the poetry was practically identical with the scoring of the prose. Nothing, therefore, need be said, unless it is that the "Judges' mark" was more or less influenced by the quality of the rhythm, rhyme, etc. For example, other things being equal, a word that rhymed with the appropriate preceding word was given preference over one that did not, even though neither of the words appeared in the original stanza.

Score, 85.

REPRODUCTION BY SUBJECT J. M.

And gentle Ellen welcomed her
With courteous looks and mild,
Thot she, what if her heart should ——,
And all be reconciled.

The sky was dark, the wind blew wild,
——— ——— ——— ———
We scarce could hear the vicar.
(There was something about a mother praying that another woman be cursed.)

Score, 39.

REPRODUCED BY SUBJECT M. K.

And genter Ellen welcomed her,
With courteous looks and mild,
Tho't she what tho her ———

The day was ————
The clouds ————
And many a night I seen more

Score, 23.

CLASSES OF SUBJECTS TESTED.

1. 40 grammar-school students. Modal age, 14.
2. 24 trade-school students. Modal age, 16.
3. 60 high-school students. Modal age, 17.
4. 24 State reformatory inmates. Modal age, 20.
5. 132 normal-college students. Modal age, 21.
6. 32 Columbia College seniors. Modal age, 22.
7. 14 Barnard College seniors. Modal age, 22.
8. 24 asylum attendants. Modal age, 25.
9. 12 workhouse inmates. Modal age, 30.
10. 24 clerks and business men. Modal age, 30.
11. 16 graduate students, instructors and professors. Modal age, 32.
12. 24 prison inmates. Modal age, 34.

Results.

The Tables.—To set forth in full the individual records of the twelve groups of subjects mentioned on page 117 would require an excessive amount of space, and I have accordingly limited the detailed presentation to two groups, one of 24 normal-college seniors and the other of 17 students in a course in experimental psychology in the same school. These subjects are all young women. Their records are given in Tables I-X, which are self-explanatory, except, perhaps, for the columns numbered 5 and 6, 8 and 9, and 11 and 12, which give the average results for the quarters and for the halves of the groups when the individuals are arranged in the order of their quickness of learning the material—which is the order in which they are arranged in the tables. Thus, in Table I, Column 5 informs us that the quickest quarter of the group (in learning 20 digits) saved 61 per cent. in relearning, the second quarter 65 per cent., the third quarter 70 per cent., and the lowest quarter 72 per cent.; Column 6 tells us that the upper half of the group, in respect to speed of learning, saved 63 per cent. in relearning, while the lower half saved 71 per cent.

Table XI sums up the results of Tables I-V in condensed form, and Table XII does the same for Tables VI-X. The column numbers in these, as also in the following tables, correspond to those in the full tables I-X.

It should be understood that the "upper half" and the "lower half" for each material consist of those individuals who fell into the respective halves of the group in the particular material studied. The upper half does not, therefore, always include exactly the same individuals, and the average results, presented in Tables XI-XVI, are obtained by combining the results of these various halves, and not by segregating the individuals who on the average learned the most or the least quickly.

Tables XIII and XIV give the condensed result for each material from two other groups of subjects, whose records are not presented individually, while Tables XV and XVI present the results from *all* the groups in still greater conden-

TABLE I.

20 DIGITS.

NORMAL COLLEGE SENIORS. GIRLS.

1	2	3	4	5	6	7	8	9	10	11	12
			METHOD THREE			METHOD ONE			METHOD TWO		
Subject	Time of First Learning, Min.	Time After One Week, Min.	Per Cent. of Time Saved or Amount Retained			Score, Per Cent.			Score, Per Cent.		
El. W.	2.25	.70	69			33			40		
Ed. W.	3.00	1.16	61			34			39		
H. B.	4.50	1.75	61	61		34	27		36	35	
F. Wi.	4.56	1.25	73			9			30		
M. K.	4.66	.50	89			37			40		
G. L.	5.00	4.33	13		63	19		26	27		34
J. M.	6.00	2.33	61			30			34		
F. K.	6.00	3.00	50			27			32		
A. H.	6.16	2.80	55	65		24	26		37	32	
R. W.	7.00	2.50	64			26			30		
C. C.	8.00	2.00	75			20			27		
H. M.	8.25	1.40	83			29			34		
A. N.	8.25	2.33	72			23			34		
M. T.	8.25	1.16	86			30			41		
F. Sc.	8.33	3.66	56	70		19	23		31	36	
F. St.	8.66	2.50	71			27			34		
B. O.	12.00	2.66	78			23			43		
S. T.	13.00	5.88	55		71	18		22	31		36
A. T.	15.00	9.80	35			9			23		
E. S.	16.80	3.50	79			19			46		
L. J.	20.16	2.40	88	72		26	20		40	36	
E. R.	20.16	2.00	90			33			47		
E. T.	21.50	5.00	77			8			22		
J. Mc.	29.00	11.50	60			26			35		
Aver.	10.26	2.76	67			24			35		

TABLE II.

20 NONSENSE SYLLABLES.

NORMAL COLLEGE SENIORS. GIRLS.

1	2	3	4	5	6	7	8	9	10	11	12
			METHOD THREE			METHOD ONE			METHOD TWO		
Subject	Time of First Learning, Min.	Time After One Week, Min.	Per Cent. of Time Saved or Amount Retained			Score. Per Cent.			Score. Per Cent.		
M. K.	12.00	4.00	67			17			49		
El. W.	13.50	5.25	61			22			51		
Ed. W.	14.00	7.00	50			52			62		
F. St.	24.25	5.50	77	68		15	26		41	47	
A. T.	25.00	8.00	68			11			31		
H. B.	26.00	4.16	84			40			50		
A. H.	26.40	4.50	83		71	37		26	49		44
F. Wi.	28.00	2.33	92			48			65		
R. W.	28.00	7.00	75			18			38		
E. S.	29.56	15.00	49	75		8	25		17	42	
F. Sc.	31.00	10.25	67			20			43		
B. O.	31.75	5.50	83			19			38		
A. N.	32.00	9.16	71			21			45		
M. T.	33.50	13.40	60			7			18		
H. M.	34.00	8.80	74			18			40		
F. K.	34.00	6.40	81	67		21	19		30	33	
J. M.	35.50	15.66	56			17			37		
L. J.	36.08	15.00	58			29			29		
C. C.	37.00	16.50	55		68	12		21	36		36
E. R.	40.80	15.16	63			39			53		
S. T.	42.00	13.00	69			14			18		
J. McC.	42.00	12.66	70	69		18	23		41	40	
G. L.	44.16	4.50	90			45			52		
E. T.	45.00	15.40	66			6			38		
Aver.	31.06	9.34	70			23			40		

TABLE III.

20 WORDS.

NORMAL COLLEGE SENIORS. GIRLS.

1	2	3	4	5	6	7	8	9	10	11	12
			METHOD THREE			METHOD ONE			METHOD TWO		
Subject	Time of First Learning, Min.	Time After Ten Weeks, Min.	Per Cent. of Time Saved or Amount Retained			Score, Per Cent.			Score, Per Cent.		
A. H.	4.40	1.00	77			43			53		
H. B.	5.00	4.66	7			12			43		
El. W.	7.00	3.88	43	45		35	26		50	44	
G. L.	7.66	4.66	39			11			39		
Ed. W.	9.00	3.08	66			31			51		
A. N.	9.50	6.00	37		40	22		23	28		44
R. W.	10.25	5.00	51			20			52		
A. T.	10.40	6.75	35			14			41		
M. T.	11.00	7.50	52	35		20	20		40	45	
E. S.	11.00	8.75	21			17			39		
B. O.	11.25	6.75	40			27			49		
J. M.	11.50	8.00	30			22			48		
F. St.	11.66	6.88	41			26			46		
S. T.	12.00	4.40	63			3			21		
F. Sc.	12.16	4.00	67	54		22	22		40	57	
C. C.	13.00	3.75	71			32			49		
M. K.	13.25	3.66	72			19			30		
H. M.	13.33	12.25	8		61	28		20	34		35
F. Wi.	13.80	4.16	70			17			37		
J. Mc.	14.00	7.25	48			16			31		
F. K.	14.33	4.00	72	68		16	18		27	33	
E. R.	15.00	3.50	77			40			50		
L. J.	16.00	2.08	87			7			38		
E. T.	28.50	13.00	54			9			17		
Aver.	11.88	5.62	51			21			39		

TABLE IV.

PROSE. 100 WORDS.

(THE DIAMOND BRIGHT DAWN).

NORMAL COLLEGE SENIORS. GIRLS.

1	2	3	4	5	6	7	8	9	10	11	12
			METHOD THREE			METHOD ONE			METHOD TWO		
Subject	Time of First Learning, Min.	Time After Ten Weeks, Min.	Per Cent. of Time Saved or Amount Retained			Score, Per Cent.			Score, Per Cent.		
Ed. W.	10.00	1.33	87			97			98		
F. Sc.	10.40	2.16	79			44			89		
A. H.	13.00	1.00	92	78		93	66		99	82	
E. S.	13.00	4.40	66			33			50		
El. W.	13.75	4.00	71			69			85		
C. C.	14.33	4.25	70		69	62		59	73		80
R. W.	15.00	4.66	69			52			78		
F. Wi.	15.25	6.00	61			45			68		
F. K.	16.08	4.50	72			39			91		
G. L.	17.00	11.25	34	59		45	53		72	79	
H. B.	17.00	5.40	63			84			87		
J. M	17.25	8.50	51			51			75		
F. St.	18.66	6.50	65			32			64		
H. M.	19.50	10.00	49			20			52		
A. N.	22.25	9.00	60	64		69	46		76	64	
B. O.	23.25	9.50	59			76			80		
A. T.	24.25	5.56	78			27			37		
M. K.	25.16	7.40	71		66	50		46	73		67
S. T.	26.08	4.00	85			42			95		
M. T.	28.00	15.00	46			46			60		
L. J.	29.80	17.00	43	68		56	47		54	70	
E. R.	31.40	6.56	79			77			89		
J. Mc.	34.56	6.88	80			49			55		
E. T.	45.16	11.75	74			14			67		
Aver.	20.84	6.94	67			53			74		

TABLE V.

POETRY. 100 WORDS.

(GENTLE ELLEN).

NORMAL COLLEGE SENIORS. GIRLS.

1	2	3	4	5	6	7	8	9	10	11	12
			METHOD THREE			METHOD ONE			METHOD TWO		
Subject	Time of First Learning, Min.	Time After Ten Weeks, Min.	Per Cent. of Time Saved or Amount Retained			Score, Per Cent.			Score, Per Cent.		
El. W.	2.08	1.00	52			36			59		
H. B.	3.00	1.75	42			95			98		
Ed. W.	3.25	.33	90			64			100		
R. W.	5.00	1.40	72	65		30	56		39	72	
E. S.	7.00	4.50	36			11			36		
A. H.	7.50	0	100			97			100		
B. O.	8.66	3.88	56		61	96		59	99		73
G. L.	8.80	6.16	30			28			50		
A. N.	9.50	4.40	54	57		57	63		55	74	
F. Sc.	10.00	2.16	78			59			87		
H. M.	10.00	5.25	48			77			82		
F. Wi.	10.16	2.25	78			60			71		
S. T.	10.50	2.00	81			10			35		
E. R.	10.56	3.80	64			78			92		
M. T.	10.75	5.00	53			51			84		
F. K.	12.25	7.16	58	62		73	43		89	65	
M. K.	13.40	5.08	62			23			44		
E. T.	13.75	6.33	54		65	24		40	48		57
C. C.	14.00	3.03	78			46			67		
J. M.	15.75	6.25	60			36			47		
J. Mc.	17.00	5.75	66	68		39	37		42	49	
F. St.	17.16	5.08	71			13			31		
A. T.	19.75	5.50	72			32			40		
L. J.	20.00	7.66	62			53			68		
Aver.	10.83	4.00	63			50			65		

TABLE A.

a	b	c	d	e	f	g	h	i
Subject.	Total Material.	Digits.	Nons. Syll.	Words.	Prose.	Poetry.	Average	Average Deviation.
El. W.....	1	1	2	3	5	1	2.4	1.3
Ed. W.....	2	2	3	5	1	3	2.8	1.0
H. B.....	3	3	6	2	11	2	4.8	3.0
A. H.....	4	9	7	1	3	6	5.2	2.6
R. W.....	5	10	9	7	7	4	7.4	1.7
M. K.....	6	5	1	17	18	17	11.6	6.9
F. Wi.....	7	4	8	19	8	12	10.2	4.2
F. Sc.....	8	15	11	15	2	10	10.6	3.6
E. S.....	9	20	10	10	4	5	9.8	4.2
F. St.....	10	16	4	13	13	22	13.6	4.3
A. N.....	11	13	13	6	15	9	11.2	3.0
F. K.....	12	8	16	21	9	16	14.0	4.4
G. L.....	13	6	23	4	10	8	10.2	5.1
H. M.....	14	12	15	18	14	11	14.0	2.0
J. M.....	15	7	17	12	12	20	13.6	3.9
C. C.....	16	11	19	16	6	19	14.2	4.6
B. O.....	17	17	12	11	16	7	12.6	3.1
M. T.....	18	14	14	9	20	15	14.4	2.5
A. T.....	19	19	5	8	17	23	14.4	6.3
S. T.....	20	18	21	14	19	13	17.0	2.8
E. R.....	21	22	20	22	22	14	20.0	2.4
L. J.....	22	21	18	23	21	24	21.4	1.7
J. McC.....	23	24	22	20	23	21	22.4	1.3
E. T.....	24	23	24	24	24	18	22.6	1.8

This table shows at a glance the rank (as to time of first learning) of each of the 24 Normal College Seniors for each of the materials memorized by her (Tables I-V). The average rank of each individual is given in Column h, and, as will be noted, compares closely with the rank for all the material shown in Column b.

sation. The entries in Tables XV and XVI correspond to the average results from all materials combined, as presented at the bottom of Tables XI-XIV.

Another way of combining the results from the use of the different materials is illustrated in Table XVII, which again is derived from Tables I-V. The 24 individuals in the group were arranged in the order of their success in each test, and were given numbers indicating their "rank" or position in the group. The table gives the rank of each individual in each performance and his average rank in speed of learning, in retention as measured by the saving method ("method 3"), in recall ("method 1"), and in recall after partial relearning ("method 2"). The average deviation of rank of each individual in each of these kinds of performance is also given. (In Appendix D may be seen the table from which Table XVII is taken.)

Finally, Table XVIII is derived from the preceding table for a purpose which will be explained later.

Time of Initial Learning.—An examination of any of the tables will reveal the fact that the time of initial learning varies widely with the different subjects, and that these differences in learning are more marked than the individual differences in relearning. In other words, it may be stated as a general rule that with a given number of individuals there will be a greater difference in their time of memorizing than in their retentive capacity.

Generally speaking, with a group of 20 or 30 subjects the time taken by the quickest learner is to the time taken by the slowest learner as 1:4. This, however, would seem to depend partly upon the nature of the material learned. Among the 24 Albany Normal College seniors (Tables I to V) it will be noticed that with *digits* the time of the quickest learner is to the time of the slowest learner as 1:13; that with *nonsense syllables* the ratio is 1:4; that in the case of *words* the ratio is 1:7; that for *prose* it is 1:5, whereas for *poctry* it is 1:10. The difference in these ratios is, of course, largely a matter of chance. Take, for example, the table for *words;* here the slowest learner takes 28 minutes and 30 seconds, whereas the next slowest learner takes only 16 minutes. It is obvious that

a much fairer form of comparison is that of comparing the average of the first four with the average of the last four. Doing this, we find that the ratios are as follows: For digits, 1:6; nonsense syllables, 1:3; words, 1:3; prose, 1:3; poetry, 1:5.[43]

An individual who is a quick learner of one sort of material tends, upon the whole, to be a quick learner of other sorts also. This is seen most conveniently in the first part of Table XVII, which shows the ranks of 24 individuals in quickness of learning five sorts of material. Some individuals stand consistently high, and some consistently low. There is, however, a good deal of shifting from one material to another, and this shifting finds expression in the coefficient of correlation between the ranking in two materials. As computed by the rank-difference method, the average correlation between the speed of learning any two sorts of material is, for this group of subjects, +.51. For the 17 subjects whose records are given in Tables VI-X, the average correlation comes out a little lower, +.42. The shifting of an individual's rank from one material to another is partly due to the accidental factors inherent in a single test, and partly, no doubt, to actual differences in the efficiency of the inidvidual's powers of memorizing different classes of material.

Interval between Learning and Reproduction.—This interval varied in different experiments, as indicated in the several tables. In the majority of our experiments the interval that was allowed to elapse for digits and nonsense syllables was either three days or one week, whereas for words, prose, and poetry it was much longer, being from three to ten weeks. In an investigation of this nature, where we are concerned primarily with acquisition as related to retention, we can, of course, choose any interval we wish. We might wait six months and still find a relation between learning and retention. That this relation would differ with the interval, however, appears probable from certain tests we have

[43] Even when we thus obtain our ratio by comparing the average of the first four subjects with the average of the last four, the P. E. is very large. It is a noticeable fact, however, and one of some interest, that with every group of subjects the greatest difference (ratio) occurs with the *digits*.

TABLE VI.

20 DIGITS.

CLASS IN EXPERIMENTAL PSYCHOLOGY. GIRLS.

1	2	3	4	5	6	7	8	9	10	11	12
			METHOD THREE			METHOD ONE			METHOD TWO		
Subject	Time of First Learning, Min.	Time After One Week, Min.	Per Cent. of Time Saved or Amount Retained			Score, Per Cent.			Score, Per Cent.		
B. B.	3.40	0.75	78			39			39		
F. Wo.	4.50	4.16	8	57		19	30		22	33	
E. F.	6.00	0.88	85			34			37		
J. S.	6.50	2.75	53		58	27		25	32		30
E. C.	6.50	1.33	80			29			35		
I. S.	8.00	1.66	79	58		35	21		39	27	
A. D.	8.56	9.66	—13			8			14		
B. C.	9.00	1.33	85			10			21		
El. F.	9.80	0.50	95			38			40		
A. Q.	10.00	3.25	68	80		24	25		32	34	
E. A.	11.00	2.40	78			20			33		
E. H.	11.30	2.25	80		81	18		24	30		32
M. J.	11.80	1.33	89			25			34		
G. H.	12.66	4.80	62			6			16		
H. A.	14.00	0.16	99	82		40	24		40	30	
R. B.	16.16	1.66	90			27			33		
M. N.	24.25	6.75	72			22			25		
Aver.	10.20	2.68	70			25			31		

TABLE VII.

12 NONSENSE SYLLABLES.

CLASS IN EXPERIMENTAL PSYCHOLOGY. GIRLS.

1	2	3	4	5	6	7	8	9	10	11	12
			METHOD THREE			METHOD ONE			METHOD TWO		
Subject	Time of First Learning, Min.	Time After One Week, Min.	Per Cent. of Time Saved or Amount Retained			Score. Per Cent.			Score. Per Cent.		
J. S.	6.08	0.75	88			29			63		
E. H.	6.75	1.33	80	84		16	37		40	59	
B. B.	7.50	1.16	85			53			72		
E. F.	9.16	1.66	82		79	49		37	60		55
E. C.	10.00	2.80	72			39			48		
G. H.	11.00	5.56	49	74		34	37		40	50	
El. F.	11.50	1.00	91			47			68		
B. C.	12.00	2.16	82			29			45		
A. D.	13.66	5.33	61			20			31		
A. Q.	14.00	3.08	78	73		32	28		40	40	
M. J.	14.25	5.16	64			18			36		
I. S.	16.00	1.66	90			42			54		
F. Wo.	17.00	9.16	46		65	12		23	19		31
H. A.	18.50	4.88	74			17			39		
E. A.	19.33	5.50	72	41		21	18		19	23	
R. B.	31.00	12.08	61			24			22		
M. N	32.56	19.25	40			10			18		
Aver.	14.72	4.74	71			30			42		

TABLE VIII.

20 WORDS.

CLASS IN EXPERIMENTAL PSYCHOLOGY. GIRLS.

1	2	3	4	5	6	7	8	9	10	11	12
			METHOD THREE			METHOD ONE			METHOD TWO		
Subject	Time of First Learning, Min.	Time After Ten Weeks, Min.	Per Cent. of Time Saved or Amount Retained			Score, Per Cent.			Score, Per Cent.		
B. B.	5.80	2.08	64			28			53		
E. F.	7.33	2.66	64	56		31	28		39	47	
E. A.	7.40	2.25	70			34			50		
F. W.	8.00	6.00	25		50	17		21	44		42
E. C.	8.56	4.50	47			21			42		
B. C.	9.16	4.66	49	45		20	15		45	37	
A. D.	9.16	6.40	30			9			29		
A. Q.	10.08	4.80	52			11			30		
J. S.	10.08	1.88	81			43			60		
I. S.	12.00	6.00	50	57		21	23		39	37	
M. J.	13.16	6.33	52			16			28		
H. A.	13.50	7.33	46		61	13		21	22		35
G. H.	14.50	7.75	47			6			21		
El. F.	15.08	6.40	58			19			35		
E. H.	15.33	4.25	72	68		12	19		28	33	
M. N.	17.00	5.00	71			19			34		
R. B.	19.00	6.08	68			39			49		
Aver.	11.48	4.96	56			21			38		

TABLE IX.

PROSE. 100 WORDS.

(THE PRESENT STUDY).

CLASS IN EXPERIMENTAL PSYCHOLOGY. GIRLS.

1	2	3	4	5	6	7	8	9	10	11	12
			METHOD THREE			METHOD ONE			METHOD TWO		
Subject	Time of First Learning, Min.	Time After Ten Weeks, Min.	Per Cent. of Time Saved or Amount Retained			Score, Per Cent.			Score, Per Cent.		
B. B.	7.00	2.88	59			57			81		
E. C	11.16	4.25	62	63		62	50		92	87	
B. C.	12.25	4.88	60			59			78		
E. F.	14.33	4.15	71		63	24		51	95		79
A. Q.	16.08	7.00	56			17			58		
I. S.	17.50	4.33	75	63		89	53		94	71	
H. A.	19.00	3.80	80			96			100		
G. H.	19.33	11.56	40			8			32		
M. J.	20.00	5.88	71			23			60		
E. H.	20.40	10.33	49	59		7	21		30	49	
El. F.	21.56	9.00	58			20			46		
M. N.	25.25	10.56	58		63	35		21	61		49
R. B.	28.16	8.08	71			18			58		
E. A.	28.40	10.25	64			43			72		
J. S.	30.00	15.00	50	66		31	21		43	48	
F. Wo.	32.66	10.75	67			8			48		
A. D.	39.50	10.66	76			6			21		
Aver.	21.33	7.88	63			36			63		

TABLE X.

POETRY. 100 WORDS.

(To See a Man).

Class in Experimental Psychology. Girls.

1	2	3	4	5	6	7	8	9	10	11	12
			METHOD THREE			METHOD ONE			METHOD TWO		
Subject	Time of First Learning, Min.	Time After Ten Weeks, Min.	Per Cent. of Time Saved or Amount Retained			Score, Per Cent.			Score, Per Cent.		
B. B.	5.16	3.56	31			59			94		
F. W.	7.00	2.50	64	55		48	57		87	83	
M. J.	7.33	2.40	67			68			84		
E. F.	8.50	3.50	59		55	53		53	68		79
E. C.	9.56	4.33	55			83			93		
G. H.	11.25	8.08	28	54		9	48		38	75	
E. H.	11.50	2.66	77			45			95		
E. A.	11.80	5.08	57			55			72		
A. Q.	12.00	2.50	79			76			98		
R. B.	12.16	0.00	100	70		85	64		100	83	
A. D.	12.16	6.56	46			5			42		
El. F.	12.75	6.00	53		72	91		50	93		76
B. C.	13.00	3.50	73			69			90		
J. S.	14.00	0.33	98			98			100		
I. S.	14.00	4.25	70	74		37	70		46	70	
M. N.	14.56	5.25	64			49			68		
H. A.	14.75	5.50	63			95			45		
Aver.	11.26	3.88	64			60			74		

TABLE B.

a	b	c	d	e	f	g	h	i
Subject.	Total Material.	Digits.	Nons. Syll.	Words.	Prose.	Poetry.	Average	Average Deviation.
B. B.....	1	1	3	1	1	1	1.4	.56
E. F.....	2	3	4	2	4	4	3.4	1.32
E. C.....	3	5	5	5	2	5	4.4	1.76
B. C.....	4	8	8	6	3	13	7.6	2.88
A. Q.....	5	10	10	8	5	9	8.4	1.52
E. H.....	6	12	2	15	10	7	9.2	3.56
M. J.....	7	13	11	11	9	3	9.4	2.72
J. S.....	8	4	1	9	15	15	8.8	5.04
I. S.....	9	6	12	10	6	14	9.6	2.88
G. H.....	10	14	6	13	8	6	9.4	3.28
F. Wo.....	11	2	13	4	16	2	7.4	5.70
El. F.....	12	9	7	14	11	12	10.6	2.08
E. A.....	13	11	15	3	14	8	10.2	3.76
H. A.....	14	15	14	12	7	17	13.6	2.68
A. D.....	15	7	9	7	17	11	10.2	3.04
R. B.....	16	16	16	17	13	10	10.2	4.28
M. N.....	17	17	17	16	12	16	15.6	1.44

This table shows at a glance the rank (as to time of first learning) of each of the 17 girls of Tables VI-X for each of the materials memorized by her. The average rank of each individual is given in Column h, and, as will be noted, compares closely with the rank for all the material shown in Column b.

made, where the longer interval gave a negative correlation. We have not studied the matter systematically, and the data here presented do not show any clear difference according to the interval employed. In general, we may suppose the difference in amount reproduced by quick learners and slow learners tends to become less, since the amounts retained by all approach zero with time.

Amount Retained.

Method 1.—Method 1 has already been described in Section 2 of the preceding chapter. It shows the amount that can be reproduced, after the lapse of a certain time interval, of the material originally memorized, this reproduction being without a fresh presentation. By consulting columns 7, 8 and 9 of any table it will be noticed that in the case of all materials, both *meaningless* and *logical,* there appears to be a positive correlation between quickness of learning and the amount retained. The score obtained by the first half[44] is, in general, better than that obtained by the last half. This is most marked in the case of *prose* and least marked with *digits.* In fact, with *digits* the score obtained by the last half is, in several cases, very nearly as high as the first half, and in the case of the high school students (Table XIV) the score of the last half is even better. In any case, however, the difference is small. With *nonsense syllables, words* and *poetry* the difference is slightly in favor of the quick learners, although, on the whole, the difference is but slight. The probable error, however, is in most cases so high that the value of index of correlation is considerably lowered. Were it not that what correlation we do obtain is positive for every table, the figures would have much less value. In the case of *prose* and *poetry* a positive correlation is unquestionable. With prose, for example, the average score for the quickest learners is, as a rule, nearly double the score for the slow learners. This, in

[44] In the following pages we shall by "First half" (or "Upper half") hereafter understand the quickest learners, and by "Last half" (or "Lower half") the slowest, or poorest, learners.

conjunction with the fact that the Pearson method gives a high index, makes the evidence practically conclusive.

Method 2.—Concerning Method 2, little need be said, the individual differences being much the same as those observed by Method 1. With the exception of *digits,* the quick learners get the higher scores. Here again the greatest difference is with the *prose* and the least with the *digits.* The most noticeable fact with this method is that it gives the highest correlation of all, and that the correlation is high throughout, *i. e.,* for all materials. The explanation of this is not hard to find. It lies in the fact that with Method 2, after the lapse of a certain number of days, the material is read once, and only once to the subject, after which reading he is asked to write down as much as possible. Obviously, the quick learner will get more from this one reading than the slow learner, and thus the index is raised.

Method 3.—So many factors are involved in this method that it calls for a more lengthy discussion than either of the two preceding. With this method the correlation is, as a rule, negative, both by the Pearson method and by the rather crude "percentage method."[45] With the percentage method we find that with digits, words, and occasionally poetry, the quickest learners retain less than the slower learners. With prose, on the other hand, the quicker learners would appear to retain more, while for nonsense syllables they stand about even.

To repeat: Method 3 gives results that by no means invariably agree with those obtained by the two preceding methods. This is due to the nature of the method, *i. e.,* to the manner of computing the "percentage of time saved" and to the treatment of this as a measure of the *amount retained.* Whether this is fair to the quick learner is questionable. According to Method 3, and, for that matter, Methods 1 and 2, those who memorize *prose* most quickly retain it better than those who memorize it more slowly. With *poetry* the same relation frequently holds, but the results are not uniform, and, as may be seen from Tables XI and XII, the quick learners

[45] By this we mean the method shown in columns 4, 5, and 6, where the percentage of the first half of the class (comprising the quickest learners) is compared with the half of the class comprising the slowest learners.

TABLE XI.

24 NORMAL COLLEGE SENIORS.[1]

		1	2	3	6	9	12
			Method Three			Method One	Method Two
			Time of First Learning	Time of Second Learning	Per Cent. of Time Saved	Score, Per Cent.	Score, Per Cent.
Digits	Upper Half		5.5	2.0	63	26	34
	Lower Half		15.0	4.0	71	22	36
Nonsense Syllables	Upper Half		24.1	6.5	71	26	44
	Lower Half		38.0	12.1	68	21	36
Words	Upper Half		10.0	5.5	40	23	44
	Lower Half		14.8	5.7	61	20	35
Prose	Upper Half		14.3	4.8	69	59	80
	Lower Half		27.3	9.1	66	46	67
Poetry	Upper Half		7.0	2.8	61	59	73
	Lower Half		14.5	5.2	65	40	57
Average	Upper Halves		12.2	4.3	61	39	55
	Lower Halves		21.9	7.2	66	30	46

[1]The "time interval" here, as in Tables XII and XIV, is one week for the digits and nonsense syllables and ten weeks for the prose and poetry. In Table XIII the "time interval" is three weeks for all materials.

The numbers heading each column correspond to the column-numbers in the preceding tables (Nos. I to X).

TABLE XII.

17 NORMAL COLLEGE SENIORS.[2]

		1	2	3	6	9	12
			Method Three			Method One	Method Two
			Time of First Learning	Time of Second Learning	Per Cent. of Time Saved	Score, Per Cent.	Score, Per Cent.
Digits	Upper Half		6.5	2.8	58	25	30
	Lower Half		13.5	2.5	81	24	32
Nonsense Syllables[3]	Upper Half		9.2	2.0	79	37	55
	Lower Half		19.5	7.3	65	23	31
Words	Upper Half		8.2	4.2	50	21	42
	Lower Half		14.4	5.7	61	21	35
Prose	Upper Half		14.6	5.4	63	51	79
	Lower Half		27.3	10.0	63	21	49
Poetry	Upper Half		9.0	4.0	55	53	79
	Lower Half		13.2	3.7	72	50	76
Average	Upper Halves		9.5	3.7	61	37	57
	Lower Halves		17.6	5.8	68	28	45

[2]The seeming discrepancies between Tables XI and XII are probably largely due to the fact that the "materials" used were not identical.

[3]In this group of subjects only twelve nonsense-syllables were used.

would appear, by this computation, to forget even more, though in any case the difference is not marked. Taking *prose* and *poetry* together, however, and assuming that they are illustrative of "logical" or "meaningful" material, we may say that the results obtained agree with those obtained by Methods 1 and 2. Taking all three methods into consideration, we are undoubtedly entitled to say that with material that is *logical* in character *those who learn quickly remember the longest.*

With digits, however, a material the memorizing of which is so-called "rote" memory we find that the conditions are, so far as Method 3 is concerned, reversed, for here it is the quick learners who seem to forget the most. With *digits* the amount forgotten, as ascertained by Method 3, is always greater for the upper half of the class, and not only is this always so, but the difference between the two halves of the class is generally marked. This result is contradicted with Methods 1 and 2, but the contradiction is slight, for, as may be seen, the "upper half" and the "lower half" are nearly equal. **At any rate, we may say with some degree of certainty that, in the main, those who memorize digits slowly are more apt to retain them than those who memorize them quickly. This is just the opposite of the statement made for prose and poetry; and digits, being an "opposite" form of material, so to speak, one might make the inference that those who learn *slowly* remember *long* if the material used is such as involves *motor associations,* but that they forget *quickly* if the material is logical in character, *e. g.,* prose, and, to a somewhat less extent, poetry.**

Such a statement, however, is true only in a very rough way. In the first place, *nonsense syllables*—a material that is not only "unmeaningful" in character, but that involves the "memorizing," so to speak, of motor associations—seems, so far as Method 3 is concerned, to side more with the *prose* than with digits. On the other hand, *words*—a material that one would think necessitated the formation of logical associations—partakes (so far as Method 3 is concerned) of the nature of *digits.* [For it may be noted the "upper half" always retains less than the "lower half."] Just why this

should be is difficult to say, and we have no satisfactory explanation to offer.

With *prose* and *poetry* our results by all three methods are quite uniform. As these materials are essentially "logical" in character, our results here do not disagree with those obtained by Henderson,[46] Thorndike,[47] or Pyle,[48] each of whom found that those who learn quickly retain more than those who learn slowly. For the material they used was not such as involved the learning of motor associations, as is largely the case with *digits*, and, with many individuals, even with *words*.

Taking all three methods into consideration, however, and averaging the results we find that with *any* material, excepting *digits*, those who learn quickest forget the least. The contrary result obtained with digits should not be considered in any way remarkable or contradictory,—the associations formed in memorizing digits being quite different from those formed in the memorizing of words and nonsense syllables. Not that logical associations are invariably formed in the memorizing of nonsense syllables, but when associations are formed they are of the same type as those formed in the memorizing of words. In short, the nonsense syllable is first converted into a word, and the word is then "memorized."

We have already considered the question concerning the degree to which the extremes at each end of a series should be considered, and whether or not they should be taken at their face value. The method of averaging the two halves of each group so that the average of the first half may be compared with the last half tends, as we have already said, to "tone down" or lower the significance of these extremes by immersing them with the remainder of the "half-class" to which they belong. Arguments may be made both for and against this procedure. In the first place, it may justly be contended that it is these very extremes that are most valuable, and that the comparison of most worth would be that in which the first two or three individuals were compared with the last two or three. On the other hand, it is possible that it is precisely these ex-

[46] "A Study of Memory," *Psy. Rev. Monog. Supp.* 1903. Vol. 5, No. 23.
[47] "Memory for Paired Associates," *Psy. Rev.*, Vol. 15, page 122.
[48] "Retention as Related to Repetition," *Jour. of Ed. Psy.*, 1911, Vol. 2, p. 311.

tremes that are most to be suspected of error, and that the chance of error is lessened by taking the average or the median of each half of the class.

Roughly speaking, the Pearson method may be said to do away with both of these objections, for, while it takes into consideration the actual amounts themselves, it tends to lower the significance of the extremes more than does the method of comparing the average of one half of the class with the other.

The Pearson method was used with every group of subjects for determining certain of the correlations considered below. It is evident that the data given in the tables supplies material for the working out of several correlations. Of these the four most important are: (1) Column 2 with 3, (2) Column 2 with 4, (3) Column 2 with 7, and (4) Column 2 with 10.

These four correlations have been worked out for every group of subjects. The large amount of figuring necessary for such a procedure may be partly seen from the table given in Appendix D—which, of course, is but for one group of subjects.

Of the four correlations mentioned, the first—Column 2 with Column 3—is, with a few exceptions, positive. The exceptions are not confined to any one material, though they occur mostly with the *digit* tables. The correlation is fairly high, averaging between .5 and .6.

The second correlation—Column 2 with Column 4—belongs to Method 3. Here, of course, the correlations tend to correspond to the relation shown by the two figures of Column 6, but this is not invariable. For example, with Tables I to V the correlations are all negative, with the exception of *prose*, and here the correlation is so low and the P. E. so large that the index obtained is practically of no value. In fact, nearly all of these "Method 3" correlations are extremely low, and their only value is to show that, so far as Method 3 is concerned, there is practically no correlation between the rapid learning and retention.

TABLE XIII.

20 COLUMBIA COLLEGE MEN-STUDENTS.

		1	2	3	6	9	12
			Method Three			Method One	Method Two[4]
			Time of First Learning	Time of Second Learning	Per Cent. of Time Saved	Score, Per Cent.	
Digits.....	Upper Half.....		3.5	1.6	49	18	..
	Lower Half.....		7.4	2.6	62	18	..
Nonsense Syllables[3]	Upper Half.....		8.0	3.7	52	22	..
	Lower Half.....		16.0	7.2	51	20	..
Words.....	Upper Half.....		6.9	2.3	66	38	..
	Lower Half.....		14.5	3.0	79	35	..
Prose[4].....	Upper Half.....		8.5	1.6	80	65	..
	Lower Half.....		13.8	4.0	72	51	..
Poetry.....	Upper Half.....		7.9	1.6	81	73	..
	Lower Half.....		11.8	3.3	73	63	..
Average.....	Upper Halves...		7.0	2.2	66	43	..
	Lower Halves...		12.7	4.0	67	37	..

[2] "Method 2" was not tried with these subjects.
[3] In this group of subjects only 12 nonsense-syllables were used.
[4] The passage of prose used was relatively easier than that used in Tables XI and XII, hence the shorter time.

TABLE XIV.

60 High School Boys and Girls.

		1	2	3	6	9	12
			Method Three			Method One	Method Two
			Time of First Learning	Time of Second Learning	Per Cent. of Time Saved	Score, Per Cent.	Score, Per Cent.
Digits	Upper Half		6.0	2.6	62	21	28
	Lower Half		14.1	3.1	74	22	31
Nonsense Syllable	Upper Half		25.3	8.0	68	30	48
	Lower Half		38.7	10.9	68	23	35
Words	Upper Half		9.5	4.8	48	25	44
	Lower Half		15.0	6.0	60	23	36
Prose	Upper Half		15.4	5.2	68	57	74
	Lower Half		26.1	10.1	61	38	60
Poetry	Upper Half		6.0	3.3	65	61	84
	Lower Half		13.6	4.7	61	51	80
Average	Upper Halves		12.4	4.8	62	39	55
	Lower Halves		21.5	7.0	65	31	48

TABLE XV.

COLUMN NUMBER.

1	2	3	6	9	12
	METHOD THREE			METHOD ONE	METHOD TWO
	Time of First Learning, Min.	Time of Relearning, Min.	Per Cent. of Time Saved	Score, Per Cent.	Score, Per Cent.
40 *Grammar School Girls. Modal Age*, 14					
Average Upper Half.....	13.2	5.0	60	37	55
Average Lower Half....	20.1	6.9	64	28	54
24 *Trade School Boys. Modal Age*, 16					
Average Upper Half....	11.4	4.2	59	35	52
Average Lower Half....	19.2	7.3	60	26	41
60 *High School Students. Both Sexes. Modal Age*, 17					
Average Upper Half....	12.4	4.8	62	39	55
Average Lower Half....	21.5	7.0	65	31	48
132 *Normal College Women Students. Modal Age*, 21					
Average Upper Half....	11.2	4.0	61	39	56
Average Lower Half....	17.8	6.4	65	31	47
24 *Asylum Attendants. Both Sexes. Modal Age*, 25					
Average Upper Half....	14.1	5.2	58	35	52
Average Lower Half....	18.3	7.2	62	28	41
12 *Clerks and Business Men. Modal Age*, 30					
Average Upper Half....	12.2	4.4	61	37	49
Average Lower Half....	20.0	7.1	67	30	39
16 *Graduate Students and Professors. Men. Modal Age*, 32					
Average Upper Half....	11.1	3.8	61	41	..
Average Lower Half....	16.9	6.1	63	33	..

The interval between first learning and relearning was, in the groups included in this table, one week for digits and nonsense syllables, and ten weeks for words, prose and poetry.

TABLE XVI.

COLUMN NUMBER.

1	2	3	6	9	12
	METHOD THREE			METHOD ONE	METHOD TWO
	Time of First Learning, Min.	Time of Relearning, Min.	Per Cent. of Time Saved	Score, Per Cent.	Score, Per Cent.
24 *State Reformatory Inmates. Males. Modal Age*, 20.					
Average Upper Half....	6.2	2.1	69	50	71
Average Lower Half....	12.2	3.9	70	43	62
32 *Columbia College Seniors. Men. Modal Age*, 22.					
Average Upper Half....	9.1	2.7	68	42	..
Average Lower Half....	12.9	5.0	70	35	..
14 *Barnard College Seniors. Women. Modal Age*, 22.					
Average Upper Half....	7.0	2.2	68	40	..
Average Lower Half....	11.8	4.5	69	33	..
12 *Workhouse Inmates. Men. Modal Age*, 26.					
Average Upper Half....	10.3	4.5	68	40	66
Average Lower Half....	16.0	5.4	69	32	54
24 *Prison Inmates. Men. Modal Age*, 34.					
Average Upper Half....	9.9	4.1	70	39	..
Average Lower Half....	14.3	5.0	72	37	..

The interval between the first learning and the relearning was, for the groups included in this table, three weeks for all materials.

The third correlation—Column 2 with Column 7—belongs to Method 1. The correlation is, with the exception of *digits*, always positive, *i. e.*, such as to show a correspondence between quickness of learning and retention when the latter is measured by the amount recalled after the interval. It is not, however, a very high correlation, seldom going above .4 and averaging only .25. As may be seen from the table given in Appendix D, the signs of the index obtained when Column 2 is correlated with Column 7* must be changed before it may be compared with the two preceding correlations, for while with Method 3 the shorter the time of relearning the *smaller* the "amount forgotten," with Method 1 the shorter the time of relearning the higher, i. e., *larger* the "score."

The fourth correlation—Column 2 with Column 10—belongs to Method 2. Generally speaking, the index obtained agrees fairly closely with that of Method 1. In view of the fact that the material is read once to the subject, Method 2 allows a certain amount of relearning and thus approaches Method 3. This is seen in several of the correlations obtained.

Even though, as just stated, the general statistical relation between speed of learning and retentiveness is very loose, it might still be true that there was a class of quick learners who were poor in retention and a class of slow learners who were good in retention. Such is the common belief, no doubt, and such a view is sometimes in psychological literature. In attempting to judge of the correctness of this view we must not be misled by chance coincidences. In a series of single tests it is almost certain to happen that an individual who learns a certain selection quickly shall be found to retain it poorly, or that one who learns it slowly shall be found to retain it well. In the absence of a general statistical confirmation of this relation a few such isolated cases have little significance. But if it is found by repeated tests of the same individual that he regularly learns quickly and regularly forgets quickly, then his case is significant as showing that individuals do exist who are distinctively quick learners and poor retainers. My tests afford some opportunity for examining this question, since each individual was tested with

*In the table of Appendix D this column is numbered "0".

TABLE XVII.

Subject	RANK ACCORDING TO TIME OF FIRST LEARNING							RANK ACCORDING TO AMOUNT RETAINED (METHOD THREE)							RANK ACCORDING TO SCORE (METHOD ONE)							RANK ACCORDING TO SCORE (METHOD TWO)						
	Prose	Digits	Nonsense Syllables	Words	Poetry	Average	Average Deviation	Prose	Digits	Nonsense Syllables	Words	Poetry	Average	Average Deviation	Prose	Digits	Nonsense Syllables	Words	Poetry	Average	Average Deviation	Prose	Digits	Nonsense Syllables	Words	Poetry	Average	Average Deviation
Ed. W.....	1	2	3	5	3	2.8	1.0	2	15	23	8	2	10.0	5.2	1	18	1	5	9	3.2	2.2	5	18	10	3	1	3.2	1.9
F. Sc.....	2	15	11	15	10	10.6	3.6	4	20	15	9	5	10.6	5.3	17	19	11	11	9	13.4	3.9	18	10	13	7	10.6	3.9	
A. H.....	3	9	7	1	6	5.2	2.6	1	19	4	2	1	5.4	5.4	2	14	6	1	1	4.8	4.1	1	9	8	1	2	4.2	3.4
E. S.....	4	20	10	10	5	9.8	4.2	15	7	24	22	23	18.2	5.7	20	20	22	16	23	20.2	1.5	23	2	23	15	22	17.0	6.8
El. W.....	5	1	2	3	1	2.4	1.3	10	13	18	14	18	14.6	2.7	6	4	8	3	15	7.2	3.4	8	5	5	4	13	7.0	2.8
C. C.....	6	11	19	16	19	14.2	4.6	12	9	22	7	6	11.2	5.1	8	17	19	4	13	12.4	4.9	13	22	18	7	12	14.4	4.4
R. W.....	7	10	9	7	4	7.4	1.7	13	14	8	12	8	11.0	2.4	10	11	13	12	18	12.8	2.1	10	19	15	2	21	13.4	5.9
F. W.....	8	4	8	19	12	10.2	4.2	17	10	1	6	4	7.6	4.7	15	22	2	15	8	12.4	5.9	16	20	1	17	10	12.8	5.8
F. K.....	9	8	16	21	16	14.0	4.4	9	22	6	4	20	12.2	6.9	19	9	10	17	6	12.2	4.6	4	16	20	22	6	13.6	6.9
G. L.....	10	6	23	4	8	10.2	5.1	24	24	2	17	24	18.2	6.9	16	18	3	21	19	15.4	4.9	15	21	4	14	15	13.8	3.9
H. B.....	11	3	6	2	2	4.8	3.0	14	16	3	24	22	15.8	5.8	5	3	4	20	3	6.6	5.3	7	10	6	10	4	7.4	2.1
J. M.....	12	7	17	12	20	13.6	3.9	20	17	21	21	14	18.6	2.9	11	6	17	10	16	12.0	3.6	12	13	17	8	17	13.4	2.8
F. St.....	13	16	4	13	22	13.6	4.3	16	12	7	15	9	11.8	2.7	21	10	18	8	22	15.8	4.8	18	15	12	9	24	15.6	4.3
H. M.....	14	12	15	18	11	14.0	2.0	21	5	9	23	21	15.8	7.0	23	8	14	6	5	11.2	5.4	22	12	13	18	9	14.8	4.1
A. N.....	15	13	13	6	9	11.2	3.0	18	11	10	18	17	14.8	3.4	7	16	9	9	10	10.2	1.9	11	14	9	21	14	13.8	3.0
B. O.....	16	17	12	11	7	12.6	3.1	19	6	5	16	15	12.2	5.7	5	15	12	7	2	8.2	4.2	9	3	16	6	3	7.4	4.1
A. T.....	17	19	5	8	23	14.4	6.3	7	23	13	19	7	13.8	5.4	22	23	21	19	17	20.4	1.9	24	23	19	11	20	19.4	3.5
M. K.....	18	5	1	17	17	11.6	6.9	11	2	14	5	12	8.8	4.1	12	1	16	14	21	12.8	5.0	14	6	7	20	18	13.0	5.2
S. T.....	19	18	21	14	13	17.0	2.8	3	21	12	10	3	9.8	7.2	18	21	20	24	24	21.4	2.0	3	17	22	23	23	17.6	6.1
M. T.....	20	14	14	9	15	14.4	2.5	22	4	19	20	16	16.2	4.9	14	7	23	13	12	13.8	3.7	19	4	24	12	8	15.5	7.1
L. J.....	21	21	18	23	24	21.4	1.7	23	3	20	1	13	12.0	8.0	9	12	7	23	11	12.4	4.2	21	7	21	16	11	15.2	4.9
E. R.....	22	22	20	22	14	20.0	2.4	6	1	17	3	11	7.6	5.1	4	5	5	2	4	4.0	0.8	6	1	3	5	5	4.0	1.6
J. Mc.....	23	24	22	20	21	22.4	1.3	5	18	11	13	10	11.5	3.3	13	13	15	18	14	14.6	1.5	20	11	11	19	19	16.0	4.0
E. T.....	24	23	24	24	18	22.6	1.8	8	8	16	11	19	12.4	4.0	24	24	24	22	20	22.8	1.4	17	24	14	24	16	19.0	4.0
Average						12.5	3.2						12.5	5.0						12.5	3.5						12.5	4.3
A. D.....						4.3							2.7							3.8							3.7	

five different materials. Table XVII, giving the ranks of 24 individuals in learning each material and in recalling and relearning it after an interval, affords an opportunity for looking for individuals who are consistently quick or slow learners, and for finding how well they do in retention. Table XVIII (extracted from Table XVII) gives the records of the most consistent individuals.

TABLE XVIII.

AVERAGE RANKS AND VARIABILITIES OF THE MOST CONSISTENT INDIVIDUALS.

Individual	First Learning		Recall (Method 1)		Relearning (Method 3)	
	Av. Rank	A. D. of Rank	Av. Rank	A. D. of Rank	Av. Rank	A. D. of Rank
Ed. W.	2.8	1.0	3.2	2.2	10.0	5.2
A. H.	5.2	2.6	4.8	4.1	5.4	5.4
R. W.	7.4	1.7	12.8	2.1	11.0	2.4
A. N.	11.2	3.0	10.2	1.9	14.8	3.4
S. T.	17.0	2.8	21.4	2.0	9.8	7.2
E. R.	20.0	2.4	4.0	0.8	7.6	5.1
J. Mc.	22.4	1.3	14.6	1.5	11.5	3.3
E. T.	22.6	1.8	22.8	1.4	12.4	4.0
General Average....	12.5	3.2	12.5	3.5	12.5	5.0

Regarding these individuals, it may be noted that:

Ed. W., while consistently high in learning and recall, occupies a medium and rather variable position in relearning.

A. H. stands high on the average throughout, but is rather variable in recall and relearning.

R. W. and A. N. are consistently medium throughout.

S. T. is consistently low in learning and recall, but variable in relearning.

E. R., the most interesting case, is consistently low in learning, consistently high in recall, and high, though only moderately consistent, in relearning.

J. Mc. is consistently low in learning and consistently medium in recall and relearning.

E. T. is consistently low in learning and in recall, and consistently medium in relearning.

There is no one, then, who is consistently high throughout,

or who is consistently low throughout, though there are two who are consistently medium throughout.

On the other hand, no one who is consistently high in learning is consistently low in retention. But there is one individual—E. R.—who is consistently low in learning and consistently high in retention; and another—J. Mc.—who is consistently low in learning and consistently medium in retention. It is reasonable to suppose that these two persons, especially the former, overlearned the material on the first learning. Through excess of caution they delayed presenting themselves for the test of learning until they were extra sure of their material, so we may suppose. If so, this moral trait of caution would produce the spurious appearance of a connection between slow learning and good retention.

Examination of Tables VI-X shows that among the 17 individuals included there is one who was consistently low in learning and rather consistently medium in retention, and one who is consistently medium in learning and rather consistently high in retention, but none who is consistently high in learning and consistently medium or low in retention.

Of the 41 individuals whose records are here presented in full, then, there is no case of an individual who can be definitely classed as a quick learner and as a poor retainer. There are several quick learners whose average position in retention is considerably lower than their position in learning, but the variability of their position as regards retention makes it impossible to place them definitely.

Intellectual Standing (*Mental Ability*).—A comparison of the results given by the various groups of subjects (*e. g.*, hospital attendants with college students) leads us to suspect that there is a direct relation between "capacity" or ability to learn and general intelligence. Most of those who have investigated this matter have arrived at the same conclusion. Jacobs,[49] for example, states that there is a "notable concomitance" between school standing and "span of prehension." Others, however, Bolton and Ebbinghaus, for ex-

[49] *Mind*, Vol. 12, 1887. Others who have obtained a positive correlation, though not so high as Jacobs, are Binet, Bourdon, Burt, Pohlmann, Smedley, Winch and Wessley.

ample, deny that any such correlation exists. Their results, however, were derived in large part from examinations of single groups that were fairly homogeneous and not by a comparison of one type of intellectuality with another.

We cannot here go into a detailed examination of all the results shown in the tables, for the reason that space does not permit giving the complete data. But we may say that, to a certain extent, the correlation depends upon the material used. It was found that where the material is logical in character, especially in the case of prose, the college graduates do better than clerks and office men of the same average age, and that these do better than asylum attendants; that college students do better than inmates of reformatories, and that Barnard College seniors do better than the female servants of the same age. The differences, however, are not marked. Upon taking any one form of material contrary results may obtain. Thus, *e. g.*, the business men and clerks do slightly better with prose than do college students of the same age, while with poetry they do worse. With nonsense syllables the order is very much the same as for prose, although here the senior college students do best of all. With digits the group of clerks and business men do better than any others, excepting the classes in experimental psychology. We cannot help but infer that this is due in a large measure to practice.

Such statements as the above, however, are more or less loose, for the reason that they refer only to *groups* of subjects. *Some* of the hospital attendants may have been more intelligent than *some* of the college students. More exact results were obtained in classes where the general rank in class of each scholar could be ascertained, all his studies being taken into consideration. An examination of the class records of the 132 normal-college students proved "that the students who rank highest in their classes and who can be classed as *the most intelligent* have, as a rule, the best memories.[50] With the group in question the correlation between memory and standing in class was found to be .31.

[50] D. O. Lyon. *Jour. of Phil., Psych. and Sci. Methods*, 1912, Vol. IX, page 74.

Social Standing (Occupation, Environment and Moral Standing).—By social standing we mean not only one's standing in society from a "worldly point of view," but also from the point of view of the sociologist. Other things being equal, we wish to determine if any one occupation is more conducive to tenacity of impression than another. It will be noted that this problem is closely linked with the preceding, and as we used as subjects prisoners and reformatory inmates, we may say that it also bears on morality.

The group differences here, like those for mental ability, differ with the materials used. The differences where the *total material* is considered are best seen by consulting and comparing the appropriate tables. With *digits* no correlations of any account were obtainable, though here, as before said, the business men and clerks seem to do better than any of the others, with the exception of the group in experimental psychology. The business men are rather slow in learning the *nonsense syllables,* and their degree of retention of these is worse than any other group, with the exception of the grammar-school students. With *words* they stand on a par with the high-school students, but for *prose* they seem to do slightly better, both for time of initial learning and for relative amount forgotten. This is what we should expect, since we have found that there is a positive correlation between mental ability and memory capacity. With the poetry, however, they do not do so well as the high-school students, and even drop slightly below the grammar-school students.

The inmates of the reformatories, and, to a slightly less extent the prisons, rank fairly high for *digits* and *words* so far as quickness of learning is concerned. For *nonsense syllables* they do not rank so high. For *prose* and *poetry* they stand very well, ranking even higher than the college students. I feel that the explanation of this seeming discrepancy lies in the fact that the minds of reformatory inmates are very receptive while in confinement. Their life being for the most part a dull monotony, they welcome any novelty, and enter upon the experiment with considerable zest. This is undoubt

edly even more true as explaining their high degree of retentiveness, for we are led to believe from a study of the "introspections" handed in that they review the material to themselves as a diversion. The average time for the criminal group is probably increased considerably by the fact that such groups invariably contain a small percentage of inmates of feeble mental mentality, either bordering on idiocy, or afflicted with one of the numerous psychoses.

Age.—Speaking of memory in its broadest sense, we may say that memory capacity increases with age. This statement is general in the extreme, in that the rate of increase varies with the material used. Generally speaking, it was found that the increase in efficiency with age is greater in the case of prose than it is in poetry, and in both of these greater than for either digits or nonsense syllables.

Several investigators have performed experiments from which they conclude that there is a state of maximal efficiency that comes in the "teens." At this period they maintain that the memory is stronger than at any other period, whether preceding or following it. To me it seems that the materials they have used have been too meager to deduce any such general conclusion. For example, Bernstein and Bogdanoff find this special "memory period" to occur about the age of 15. The only material they used on which they based this conclusion consisted of geometrical figures. To me it seems that the only conclusions one can derive from such an experiment is to say that when geometrical figures are presented to various subjects in a certain way and then tested for recognition after the lapse of a certain interval, the subjects around the age of 15 do, on the average, better than older students and adults.

With Method 1 I find that high-school students averaging from 16 to 17 years in age retain more of the poetry than do the younger grammar-school students and the older college students. With prose the height of efficiency, as before said, appears much later in life, and the more abstract and difficult the material, the later it appears. This would probably have its limit, however, and even with Kant's "Critique" men of

50 would undoubtedly do better than men of 80. The difficulty experienced by the younger children in memorizing a nonsense syllable is undoubtedly ascribable to many causes. Probably the chief of these is that nonsense syllables are uninteresting, and though children may have a better retentive capacity than adults, their attentive capacity is decidedly inferior.

Sex.—Our object here is to discover if there is any difference in retentive capacity between the male sex and the female sex as a whole, and in particular if there is any difference between the sexes in the relation of the time of learning to the amount retained.

An examination and comparison of my tables (including some not here reproduced) show that as a whole the women and girls do better in their initial learning than do the men and boys. Thus, *e. g.*, the Barnard College girls memorized the total material in a shorter time than did Columbia College men of the same age. For *digits, words, nonsense syllables* and *poetry* the girls average better than the boys. With *prose* the women do better with the passage starting "The diamond bright dawn,"—the men, with the passage starting "The present study of monistic philosophy," but the difference in each case is small. These statements apply only to time of first learning. When we come to *retentiveness*, as ascertained by averaging Methods 1, 2, and 3, we find that though the girls still hold their superiority over the men for *digits, nonsense syllables*, and *poetry*, the men stand equal with them in the case of *words*, and for prose even do better.

Summary and Recapitulation of the Main Results.

In the preceding chapters we have endeavored to set forth, more or less in detail, the various results obtained from the experiments performed. In a few cases conclusions were drawn, but in the main they were reserved for the present chapter.

Any attempt to classify these conclusions in a strict and exact manner meets with failure. An analysis of them, how-

ever, shows that they may be roughly put under two groups: (1) Those relating to methods and modes of experimentation and correlation and that partake more of the nature of *inferences;* (2) those results that are drawn from the experimental data given in the tables, be their limitations and imperfections what they may. We shall now give a brief recapitulation of the results, conclusions and inferences of these two groups. (Several of the following have been drawn from an examination of the "introspections.")

Group 1.—(1) Memory is not a distinct, separate and concrete faculty of the mind, but is complex in the extreme. Experiments such as those described in this and the preceding chapter, being limited in character, apply but to a small part of mentality—and hence memory.

(2) *Association* and *retention* are closely related. It is a question as to how much we should consider the former in investigating the matter.

(3) Memory should not be confused with attention, nor should this latter even be considered as part of it. We have found that many of the experiments that are supposedly performed on memory are really experiments on attention—or on attention combined with some other faculty.

(4) The *relation* of quickness of learning to retentiveness depends upon the method used of ascertaining this "retentiveness." The different methods (*v.* p. 98) give opposite results, and yet, in one sense of the word, one method is as "correct" as another.

(5) Two people may have equal degrees of retentiveness, but very unequal degrees of reproduction. To test briefly the power to recall is but to test a certain factor of memory.

(6) With the same subjects and the same method of experimentation, different materials give different results.

(7) In testing "memory" when taken in the fullest sense of the word we should test not only the so-called "rote" memory, but we should also consider the subject's ability to perceive relationships and associations, and his ability to memorize them.

(8) In relearning it is impossible to distinguish a facility of forming new associations from a retention of subliminal associations. This disadvantage is carried by Method 3.

(9) "Method 1" has several drawbacks. The chief of these is that reproduction without a fresh presentation of the material originally learned reveals only the strongest of the original impressions—the so-called "supraliminal associations."

(10) An examination of over 400 "introspections" would seem to show that it does not pay to attempt to multiply the various forms of imagery. The quickest learners employ the type, or combination of types, to which they are naturally accustomed.

(11) A factor that must be taken into consideration in investigating retention is the general attitude of the learner toward his work. If he is much interested in the problem in hand and takes great interest in his task, he naturally takes more care, and consequently is able to retain longer than another who has not this same feeling of interest. Where there is *zeal* and *desire* in learning, there follows an earnestness and interest in the work which will eventually result in greater retentiveness. This is particularly noticeable in the tests on subjects who are working in psychological laboratories,—subjects interested in experimental psychology.

Group 2.—(1) With any given number of individuals it may be stated as a general rule that they will differ more in the time they take to memorize than they will in retentive capacity.

(2) The students who stand highest in their various studies and who prove upon examination to be "the most intelligent" have, as a rule, the best memories. They not only learn more quickly, but they retain better.

(3) Those who employ logical associations and visual imagery in the memorizing of a series of words or nonsense syllables recall them more slowly than do those who memorize in an *auditory* or *motor* manner. The latter type of subjects reproduce the associations easily and quickly immediately after the first learning, but forget them just as promptly.

(4) As a general rule it is best to memorize thoroughly before attempting to recall. When in doubt, do not waste time and form confusing associations by continuing the attempt, but consult the text immediately.

(5) In general, the women and girls do better in their initial learning than do the men and boys. In *retentiveness,* however, the men and boys are, on the whole, slightly superior, but this is not so for every material.

(6) The quickest learners tend to learn their material more *as a whole* than do the slower learners, and this is invariably so with the *second learning.* The quick learner only divides his material into parts when he is totally unfamiliar with it.

(7) The quick learners tend more to employ *rhythm* in the learning of digits, nonsense syllables and words than do the slow learners. If the element of rhyme or rhythm enters, it aids the ability to reproduce after learning. Those who learn by means of rhythm can somehow or other reproduce better than those who do not employ such methods of rhythm.

(8) The relation of quickness of learning to retentiveness depends on many factors, the most important of which are *method, material,* and *interval.*

(9) A change in the interval does not affect different forms of material to the same degree.

(10) As to the relation of quickness of learning to retentiveness, the most general statement that can be made is that those who learn quickly remember longest if the material is logical in character. Where the material is "illogical," especially if it is memorized by "motor associations," the converse is true. This, however, has many exceptions, depending both upon the material and upon the method used. The exceptions are most notable in the case of nonsense syllables and words.

(11) There would appear to be a positive correlation between quick learning (be it of sense or nonsense material) and retention of logical material (ideas). The correlation, however, is low. Quick learning is no guarantee that the time of retention will be relatively long. We should not consider *economy in learning* merely as *economy in time spent in learning.*

(12) By Method 1 the score obtained by the first half of the class is invariably better than that obtained by the second half.[51] The difference between the first quarter of the class and the last quarter is naturally even more marked. The difference is found to be greatest in the case of *prose* and least in that of *digits*. With *prose* we frequently find that the first quarter of a class of 24 will remember (by Method 1) half as much again as the last quarter.

(13) The experiments on school children show that girls from the years of 10 to 24 learn more quickly than boys of the same age. The results also show that the number of retained members of any series increases from year to year.

(14) There is a positive correlation between education and memory. Inmates of prisons and attendants in State hospitals do not do as well as boys of 15 years of age. Education thus has much the same effect upon retentiveness as has age.

(15) With both nonsense syllables and words the first few syllables (or words) of a series are retained longer than those in the middle of the series.

[51] Excepting in the case of two groups of subjects, the *digits*.

CHAPTER V.

THE EDUCATIONAL VALUE OF PSYCHOLOGICAL RESEARCH,

with special reference to ECONOMY IN LEARNING and MNEMONIC SYSTEMS.

Meaning of "economy in learning." Multiplicity of factors to be considered. Because a method is the most economical in *time* does not mean that it is really the most economical. *Permanence of retention* and *facility of use* of greater importance than amount of time spent.

"Sçavoir par cœur n'est pas sçavoir."

Mnemonic systems. No limit to the number of digits the mnemo-technician can recite. The mnemo-technician assumes an excellence of memory that in reality he does not possess.

Forgetting. The process of forgetting a selective one.

Psychology in its relation to the science of education. Practical value of the results of psychological experimentation. Scientific conclusions as a rule are but relative and subject to change. The introspective method v. the experimental method. A large part of the writings of introspective psychology consist of loose, indefinite and unwarranted generalizations that have never been subject to experimental investigation. Only by experiment can we learn the truth. Experiment slowly changing the general aspect of the old psychology. Exp. psych. has performed its best services in correcting erroneous ideas concerning the mind's actions. Exp. psych. still in its infancy.

Psychology still remains in large part a science of probabilities based on experimental data the validity of which is frequently doubtful.

It will have been noticed in the preceding pages that several problems of interest to pedagogy have been touched upon. The chief of these is probably that of economy in learning.

A definition of economical learning is not as easy as it may at first sight appear. We are too much in the habit of considering that economy in time and economy in learning are synonymous terms—that a saving in the one means a saving in the other. In judging the degree of economy in any certain method of learning the following points should be considered: (1) Amount of time spent; (2) amount of labor (energy or mental force) expended; (3) length of retention; (4) amount (completeness) of retention; (5) fidelity and exact-

ness of reproduction; *a*,—as to the wording—or acquisition of elements; *b*,—as to the idea—or formation of associations; (6) rapidity of reproduction; (7) degree of comprehension or understanding (this includes form of imagery employed as well as nature and amount of association employed).

It will be seen that the problem is not a simple one, and that the relative proportions of the factors we have mentioned may vary with the same individual, this depending upon the nature of the material and the purpose for which it is intended. The aim—or goal—of learning is not always the same, and what may be considered as an "economical" method for one form of material may not be for another. In studying his lessons the average schoolboy's sole aim is to be able to repeat once, and once only, the knowledge before him—to answer the question when called on. Acquisition with much a similar aim is, however, also witnessed in the adult, *e. g.*, in the minister with his sermon, the politician with his speech and the actor with his piece. What we wish to emphasize here is that though a certain method may result in leading rapidly to an immediate recitation, it does not follow that it will be the most economical method where permanent retention is desired. As we have already seen* a certain method may consume a greater amount of time, but secure the desired effect, viz., that of permanent and lasting retention. It will be seen that no set rule can be laid down. Generally speaking, all that we may say is that that method is the most economical that attains the end desired (1) in the shortest time, (2) with the least trouble,** and (3) with the minimum degree of fatigue.

The seven factors that we have mentioned are not all equally susceptible of measurement. Time can be measured with a watch—and in like manner length of retention. But to measure the amount of mental work—the amount of *energy* expended—is not so easy. A few things, such, for example, as number of repetitions during a stated interval, may be taken into consideration and thus help us in forming an opinion, but this must always rest but approximate.

*We refer to the "once-per-day" method.

**A "twice-per-week" method, e. g., may be economical as far as "total time" is concerned, and not at all fatiguing, but its observance may be extremely troublesome and annoying.

It is not always an easy matter to differentiate economy in time from economy in force. Not only is the actual amount of mental force saved by the use of a certain method impossible of determination, but we are unable to state the *relationship* of the force saved to the time saved. A saving in time may or may not at the same time represent a saving in force. In short, about the only definite statement that we can make—and one that is self-evident—is that of two methods demanding equal mental force (both quantitatively and qualitatively), and where the length of duration* is the same, that method is the most economical that necessitates the least expenditure of time. It should be borne in mind, however, that a saving in time may be accompanied by such a greatly-increased expenditure of energy that no true economy can be said to take place. In like manner, although a certain method may result in a saving in *time of first learning*, the amount of time the material is retained may be so short that no true economy may be said to have resulted.

But this is not all. Not only must we define what we mean by "economical learning," but we must define what we mean by "*learning.*" In our Introduction we endeavored to show that both "learning" (in the sense of *knowing*) and "memory" were extremely vague and indefinite terms. We there stated, by way of example, that, although a person may be able to repeat a list of words, he may yet, in one sense of the word, not really know them. This we exemplified by way of one who learns a set of words by using only his motor-auditory memory. We are probably safe in assuming that most people recite the Creed or the Lord's Prayer in this manner. The prayer is started and goes on automatically, the subject's mind being occupied with other affairs.

The same is, to a large extent, true of all that we learn when we use merely our auditory or auditory-motor memory. Teachers and educators have recognized this for some time. "Sçavoir par cœur n'est pas sçavoir," said Montaigne. A similar truth was recognized by Kant. "When a child," said he, "does not put into practice a rule in grammar, he cannot strictly be said to know it, even though he may be able to

*Permanence of retention.

recite it. On the contrary, he who invariably applies a certain rule may be said to *know* this rule, even though he may not be able to recite it. The best method of comprehension, therefore, is to *do*—to *use*—to *act.*" That which one learns the most thoroughly, and which one remembers the longest, is what one has realized the truth of, or has learned or invented by himself.

In discussing economy in learning, therefore, the question is not only alone one of what will give the best result as to economy in time, but what will give the best and most comprehensive understanding. The astronomer who says "the distance to Mars from our earth is 35,000,000,000,000 miles" knows the fact in a way altogether different from the schoolboy who repeats the same words. In like manner, however, the schoolboy may be said to know this better and in a different manner from the savage who may be taught to reproduce, in a parrot-like manner, the same sentence. We may observe a similar, though not identical, case in a simple problem in multiplication. A child may be able to give the correct answer for 8×9, and yet fail on 9×8. The fact of the matter is that he has learned only the formula "$8 \times 9 = 72$." He falls down on 9×8 because he does not know in as complete a sense as he should the meaning of "$8 \times 9 = 72$." The case is similar, but not identical, with that which we gave of the astronomer. In one sense of the word, $8 \times 9 = 72$ is no more the same as $9 \times 8 = 72$ than BOX is the same as XOB.

While on this matter we cannot do better than quote from Wells—in an article* which, though not directly on the point in question, is nevertheless extremely elucidative:

"Pragmatically, to know a thing is to have established an association or co-ordination path which causes us to react according to it. We know a thing more certainly according as we react more certainly or in any way more effectively as though that thing were so. Though the certainty has a different source, you do not know that two and two make four more certainly than the dervish knows that the prophet's paradise awaits him on death in battle for his faith. To say that one

*"A Note on the Retention of Acquired Capacities," *Amer. Jour. of Psychol.*, 1915, Vol. XXVI, pages 66-67.

takes a few sigma longer to add six and five than one did two years ago, is another way of saying that he does not know their sum so well." The lesson to the teacher and educator should, however, be obvious: See that the child knows (understands) as completely as possible whatever he may have to learn, and call in the "logical" memory in preference to any other form.

With some of the subjects experiments were performed to ascertain the time necessary to memorize the nonsense syllables and words in the reverse order. One might imagine that those subjects who knew the list best (in the original order) would be able to relearn it quickest in the reverse order. Although this was frequently the case, the inference is unjustifiable. Because one knows a poem by heart does not mean that he can repeat it backwards. Some subjects take almost as long to relearn a series of syllables backwards as they took to memorize them in the first place. The difference depends to a great extent upon the manner in which the work was originally performed—the form of imagery used and the nature of the associations made.

In discussing economy in learning *permanence of retention* and *facility of use* are of greater importance than *amount of time spent*. As we have seen in Chapter III, with the continuous method the time of learning may be relatively short, but the permanence of retention relatively poor. Permanence of retention and amount of time spent are capable of being measured, but, owing to its complex nature, *facility of use* is more difficult of precise measurement. As we have already stated, a man may be able to repeat a set of words and yet, in one sense of the word, not know them. The same remark may be more or less applied to digits. The remark is strictly applicable when the acquisition[1] of the digits depends upon the employment of a mnemonic device.

Several mnemonic devices exist for the "memorizing" of long lists of digits. One of the most commonly used is the following: The subject commences by establishing a bond or relationship between the ten digits and the various con-

[1] In the case of the mnemo-technician we can hardly use the word *memorize*.

sonants of the alphabet. To him each digit invariably stands for and is represented by a certain consonant. It is obvious that to the individual employing such a system it is but a very simple matter for him to replace each number by its appropriate consonant. For example, 582783 is replaced by *l, ng, r, d, s, nd.*, because to him 5 corresponds to *l.*, 8 to *ng.*, 2 to *r.*, 7 to *d.*, 8 to *s.*, and 3 to *nd.*, etc. With these consonants before him he has a skeleton, so to speak, on which he can work. In order to create a phrase for them it is necessary that he introduces vowels. In this he allows himself the greatest liberty, putting them in wherever and in any number that he may desire. Thus, for example, with using the letters *l, ng, r, d, s, nd.* he may invent the phrase, "long roads end."

As a matter of fact, the mnemo-technician ascribes to each digit two or more letters or combination of letters, thus giving himself a larger selection, and, therefore, a greater facility of forming a phrase. For example, the figure 4 may be represented by *ze* as well as by *se,* and the figure 6 by *te* as well as by *de.*

It is thus obvious that, given any reasonable number of digits (not more than 100 or 200), the mnemo-technician has no great trouble in preparing and memorizing his prose or poetry to fit them. All he has to do is to learn by heart the phrases he has formed—an affair that for 100 digits may not take more than fifteen minutes. It will be remarked that the process employed by the mnemo-technician in a case such as this is one of *substitution, i. e.,* in place of committing digits or numbers to memory he commits phrases or sentences. In short, he translates his numbers into words, and with these he forms ideas that are relatively easy of retention. It will, of course, be remarked that the mnemo-technician cannot use the same phrase several times unless it so happens that the digits presented to him repeat themselves—an affair that is not probable if the digits are selected by chance. However, in view of the fact that he can (if he has an average memory) commit one-thousand lines of prose or poetry in one sitting, he thereby has at his command some ten or twelve thousand

digits. As he is able to repeat these in exactly the same order as many times as he may be called upon to do so, he appears, to the ordinary observer, to have actually "memorized" them.

If, however, the mnemo-technician is *himself* allowed to select his digits, the number that he is able to acquire is practically unlimited. He may with ease recite three or four hundred thousand, even one million, and then, if called upon to do so, repeat them in exactly the same order. When once the method employed is understood, the seemingly remarkable feat becomes most commonplace. The way in which he works is as follows: Placing before him an easy and interesting poem (of, say, a couple of hundred verses) that he has previously learned by heart, he substitutes, using the poem as a skeleton or framework, the consonants in each word with digits. Years of practice in this work give him such a facility in this "substitution work" that he is able to "see" the appropriate digits stand out before him as he recites (to himself) his verses. The process is one of *translation,* so to speak. A couple of hundred ordinary verses will furnish him with about two thousand digits. Having finished these, he has only to again recite them, this time, however, increasing the number by one as the digit "comes" to him or *appears* before him. Further variations are made by *subtracting* one or by adding two, three, four, etc. It is thus evident that, without any great expenditure of mental energy, he may recite and re-recite one million digits—an affair that, on the face of it, would be impossible for brute memory to accomplish. In fact, when the digits are more than one hundred in number, even the most experienced of the lightning calculators cannot compare with the mnemo-technician. A comparison of the times taken to memorize digits between the mnemo-technician (Mr. Arnould) and the lightning calculator (Mr. Diamandi) may be seen in the following table, which we borrow from Binet's[2] most excellent work on that subject:

[2] A. BINET. *Psychologie des Grands Calculateurs*, Paris, 1894, p. 173.

Number of digits acquired.	Time necessary for acquisition. Mr. Diamandi.	Mr. Arnould.
10	17 s.	20 s.
15	1 m. 15 s.	1 m. 45 s.
20	2 m. 15 s.	2 m. 30 s.
25	3 m.	2 m. 30 s.
30	4 m. 20 s.	2 m. 45 s.
50	7 m.	2 m. 45 s.
100	25 m.	15 m.
200	1 h. 15 m. 20 s.	45 m.

As may be seen from the table above, it is only when the digits are less than twenty-five or thirty in number that brute memory (be it even of a Diamandi) can surpass the performance of the mnemo-technician. For example, to learn twenty digits takes Mr. Arnould 2 m. 30 s., whereas Mr. Diamandi takes but 2 m. 15 s. With twenty-five digits the respective times are nearly equal—Arnould, it will be seen, took 2 m. 30 s., Mr. Diamandi 3 m.[3]

8 6 4 3 9	Vieux faucheur aime bien.
2 5 7 6 2	Nie le cas, ou échafaud.
3 1 7 3 5	A moi ta gamelle.
5 1 8 4 3	Là — tu veux ramer.
2 3 5 8 1	Un homme à la fête.

A comparison of the results obtained by the mnemo-technician with a native memory such as that of Mr. Diamandi is both interesting and instructive. One remarks that with increased number of digits there is naturally an increase in time, but the increase in the two cases is not proportionate.

Mr. Arnould is a mnemo-technician by profession, and frankly admits that his work is one of simulation and deceit; he assumes an excellence of memory that in reality he does not possess. His work, as we have said, consists in substituting ideas for numbers, or, to put it in other words, he gives to numbers an artificial significance which permits of their being easily retained and recalled. Other professionals are not so frank, and it is not always an easy matter to distinguish the mnemo-technician from the individual who in reality *does* possess a remarkable memory for digits. In order to differentiate between the two an examination should be made

[3] As an illustration of the method employed we give below the phrases and sentences employed by Mr. Diamandi during an actual reproduction by him of twenty-five digits:

along the following lines: (1) Number of digits capable of being memorized, *i. e.*, extent of memory; (2) rapidity of acquisition; (3) rapidity of repetition—verbal repetition; (4) length of time remembered.

* * * * * * *

In connection with economy in learning it is necessary that we discuss *forgetting*. The process of forgetting is more or less based upon one of *selection*. In order to have an effective logical memory we should not burden ourselves with the unessential. The act of forgetting judiciously, therefore, is as important a function as that of retaining judiciously. "Selection," says James, "is the very keel on which our mental ship is built. If we remembered everything, we should, on most occasions, be as ill-off as if we remembered nothing." Our memory of each day's events is constantly disappearing and being obliterated. Passed in review, after a few days' interval but few of the sensations previously received, ideas previously formed and emotions previously felt can be recalled; "most of them have made shipwreck in that great nonentity from which they never more will emerge" (Ribot).

It is not, of course, to be understood that the line of demarcation is sharp and distinct—that is, that knowledges are *either* forgotten *or* remembered. There are various grades. Upon analysis the problem resolves itself into one of *amount*—of *amount recalled*.

It is obvious that a distinction should be made between total recall and partial recall. Some events are recalled in detail with a complete "setting," so to speak; other events, on the contrary, are recalled in a vague, indefinite and incomplete manner, and merely the "skeleton," as it were, is seen. Theoretically, total recall, in the sense of perfect, complete and absolute recall, never occurs, nor would it be often desirable. To have to recall all of the details without the power of omitting the unessential would be most undesirable. Generally speaking, the well-ordered mind is distinguished by its ability to omit the unnecessary and unessential. We witness this with the story-teller. The good story-teller knows what to bring out and what to select in order to produce the effect and emotion that he desires; the poor story-teller, on

the other hand, not having the power of selection developed to such a degree, dwells so long on the unessential points and lays such emphasis on unimportant matters that he misses the drift and arrives nowhere.

As a rule, this power of proper selection of ideas and control of the imagination is more or less concomitant with age and education. The educated man is distinguished by the facility with which he can pass from total to partial recall, and the aptness with which he is able to throw off the unessential. In short, he is characterized by his ability to forget judiciously.

As we have already said, perfectly total recall really never occurs. What we mean by it in this discussion is a recall where the various experiences and emotions are revived in all their minutiae. Such recall might be valuable in scientific work and in the witness-box, but nowhere else.

* * * * * * *

In a thorough investigation of economy in learning the question should, of course, be considered as to whether the use of a combination of two senses may not be better than either alone, *i. e.*, may not the employment of two or more senses be more economical, and at the same time give a higher degree of retention. The results obtained by the various experimenters who worked on this problem vary widely.

Among the most precise experiments performed on this subject are those of Münsterberg and Bigham.[4] These authors compared visual memory with that of auditory (or auditory-motor) memory. In the experiments to which we refer Münsterberg and Bigham used as material small squares of colored paper. Each square was of a different shade of color; they also employed other squares of white paper on each of which was written a number that the subject had previously memorized in connection with or standing for a certain definite shade or color. Thus, the number 5, for example, stood for blue; 7, for yellow; 6, green, and so forth. In this manner it was possible for a subject to memorize a series of colors (in an auditory manner) by digits as well as by names. Their

[4] MÜNSTERBERG. *Studies from the Harvard Psychological Laboratory.* Psych. Rev., Vol. I, p. 34.

subjects were but five in number, and their results, therefore, have but a limited value. We cannot here discuss the results of their experiments and their conclusions, which are somewhat complex. We shall merely say that they found that: (1) Visual presentation of color gave a higher degree of retention than did mere auditory presentation.

(2) A series of tests presented at the same time to two different organs of senses give a higher degree of retention than when one is presented to the eye alone or to the ear alone. [In certain cases, however, the employment of two senses is undesirable, the one seeming to act against the other.]

Others who have worked on this problem of Economy in Learning are Steffens, Pentschew, Jost, Meumann, Schneider, G. E. Müller, H. Müller, P. Ephrussi, Neumann, Witasek, Radosavljevich, Gamble, Busemann, Ogden, Lakenan, Larguier des Bancels, and Pyle and Snyder. The more important of the results obtained by these investigators have been already given (in Chapters III and IV.)

* * * * * * *

It has become so customary of late to associate the science of Education with that of Psychology that it is common for those not working in psychological laboratories to infer that a considerable, if not a major part, of psychological experimentation is performed with the sole purpose of furthering educational advancement. The inference is an erroneous one. It is only here and there that the results obtained by the experimental psychologist are of any great value to the teacher or educator. Experimental psychology has made but few changes in the science of education, and we have no reason to assume, as we so often do, that the latter is based and founded upon the former. It is only when psychology applies itself strictly to educational problems that results of any moment to the teacher may be expected, and here again the "results" were quite probably already known to the educator in a more or less vague way.

In short, a large percentage of the results obtained by the experimental psychologist are all very well as facts—scientific

facts—but they have little to do with every-day life; at any rate, to the average man they are unemployable. We should here say, however, that experimental psychology and its applications are distinct, and that it is not necessarily the duty of this science to confine itself to matters of practical import. The true investigator centers his attention solely on the search for truth, irregardless as to whether the results he obtains may or may not be of practical application. This may seem somewhat by way of defense—as though we were trying to defend the experimental psychologist and justify his existence. He does not need defense. Apart from what we have said, we cannot but suspect that he invariably hopes that the results he obtains may be of practical value. The zoölogist who spends months and years in the study of the chromosomes of the fruit fly *Drosophila ampelophila*—crossing red-eyed females here with white-eyed males there, or individuals of the "vestigial" winged variety here with individuals of the "long-winged" variety there—doubtless hopes that some day he will be able to tell us just what determines sex in man—possibly even, how to control the sex of his offspring. To the breeder such a discovery would certainly be of great economic value. In short, with all such work the practical man of affairs may fail to see the connection, but it is nevertheless there. And so with a considerable part of the experimental work that has been done on MEMORY;—no true educator can behold the results without perceiving that here are exact knowledges—knowledges which, though they may not be directly applicable, must none the less have a bearing of some sort on the learning process and, therefore, on EDUCATION IN GENERAL.

It is when the psychologist applies himself to the study of memory that the teacher awaits most eagerly for the results, but even here his conclusions are generally disappointing. "Do not endeavor to improve the memory"; "Do not break the material to be learned into parts, but learn it as a whole"; "Avoid mnemonic devices"; "Trust the memory wherever possible"—these and possibly a half-dozen other rules tell us all that the teacher will receive from the psychologist on memory. The great trouble is that even here the psychologists

differ even among themselves. Some tell us that the memory (memory in general) *is* capable of improvement; others tell us that it is incapable of improvement, and that as it is given us at birth, so it remains.

All this is in no way meant to disparage the science of experimental psychology. We desire merely to limit the idea that experimental psychology—even when applied to memory—must necessarily yield results that are of great practical importance, or that are so exact and well defined that no difference of opinion may exist. Conclusions in science—even when the data on which they are based are of the best—are but relative and subject to change at short notice. The conversion or alteration of scientific "facts" is more apt to mean that the original conclusions were too hastily drawn than that the data were wrong. Thus in the field of memory e. g., it may be that the "piece-meal" method of learning is, for general purposes, the most economical, nothwithstanding that the results obtained by Steffens, Ephrussi, and others, would seem to point to the contrary. As we have already said, economy in learning depends upon the object or result that is directly desired. In short, we must define what we mean by "economy." Thus it is that no determination of the economy of a method can ever possess universal validity. We can only say what method will give the best results—will be the most economical—for the object the learner has in view. Such results as those obtained by Steffens, Pentschew, Ephrussi, Pyle, and Jost are relative in the extreme, though, with the exception of the two latter, these authors have failed to appreciate the fact.

It is the habit of each science to extend the basis of its knowledge by experiment, and psychology is far from being an exception. But psychology is not an exact science, and thus it is continually tempted to make generalizations from imperfect observations or too small a number of observations, and it is constantly the work of the experimental psychologist to check up the inductions and theories of his "arm chair" colleagues. The desire to form theories is at all times laudable, but with so inexact a science as psychology they should be formed with great care—and then only after careful and

repeated experimentation. If for no other reason than the great diversity of opinion held among psychologists regarding the laws of the mind, it behooves us to demand an increase in both the exactness and number of the data before forming generalizations. Psychology is not able to express its laws with the mathematical exactness that characterizes chemistry and physics—and, notwithstanding that mathematical formulas are being more and more applied to certain operations of the mind, psychology remains in large part a science of probabilities based on experimental data the validity of which is frequently doubtful.

Psychology is, however, trying, and becomes every day a more exact science. For this she may thank both Education and Psychology for the demands put upon her; these sister sciences have formed an inseparable trio, each asking questions of the others. We are no longer satisfied with rule-of-thumb methods, and now demand the how, why, and wherefore of each and every operation.

The major part of the literature on the mental sciences still consists of loose, indefinite, or unwarranted generalizations that have never been subjected to careful experimental investigation. This is especially true of the old psychology, and so it is that experiment is slowly changing the general aspect of this science. This, then, is the chief task of the experimental psychologist—the accumulation of data in so great a number and on so many subjects that generalizations may be safely deduced. Modern psychologists have more or less abandoned the exclusively introspective methods as employed by their arm-chair brethren, and have turned to experiment. Deduction has given way to induction. We shall not say they are going too far, but as yet it must be admitted that, although a few erroneous conceptions concerning the mind have been corrected, Psychology as a science has not been revolutionized. Unfortunately, a considerable portion of the results that have been obtained are as yet either not amenable of application or are of doubtful validity. Parmelee is undoubtedly correct in saying that the prime need in psychology to-day is the development of its genetic aspect. Here, by tracing the evolution of psychic phenomena from the lowest up to the highest

species, and by keeping in mind that psychic phenomena can be profitably studied only from a viewpoint of objective behavior, it may be that a considerable amount of useless experimentation on human beings will be done away with.

Experimental Psychology has performed its best services in exploding erroneous ideas regarding the mind—many of them so old that they were uprooted with difficulty. For example, it has long been held that improvement in one operation of the mind may materially improve others. Thorndike and Woodworth, however, in their paper entitled "The Influence of Improvement of One Mental Function Upon the Efficiency of Other Functions," have conclusively proven that such is almost never the case. Again, for example, it has long been held that the brain is liable to fatigue, in much the same way as one of the muscles. "Common observation," says Woodworth,[5] "seemed to show that fatigue comes on very quickly in mental work, and this apparent fact has done duty in many psychological explanations." Experiments, however, have shown that this familiar form of fatigue is largely a sensory or emotional affair. "It is a feeling of fatigue, not a true fatigue in the sense of incapacity."[6] In the field of memory experimental psychology has done great service in exposing numerous "systems" for the improvement of memory as well as the mnemonic devices supposed to facilitate retention and reproduction. Now psychologists are supposed to hold definite ideas regarding such themes as these, though it would seem that the public pay but little attention to them. The reason for this lies partly in the fact that in matters relating to the mind there is so much charlatinism the psychologist hesitates to popularize his subject. Scientific psychology may definitely prove some prevalent idea to have no foundation, but he may not send the exposure broadcast. In the meantime, the professional memory teacher acquires fame and support from a public that ought to know better.

We have already said that now and then the results ob-

[5] *Psychiatry and Experimental Psychology*, Proc. of the Am. Medico-Psy. Ass., June, 1906.

[6] Op. cit.

tained from psychological experimentation may be of value to the teacher, and that when it came to memory, nearly every investigation contributed some gain, small though it may be. What, now, are the contributions that such experiments as those described in detail in Chapter IV may make to the science of education? For answer we can only refer the questioner to the summary of results given at the end of the chapter in question. It may, for example, be of value to the teacher to know that a rapid learner is at no disadvantage so far as his retentiveness is concerned, but, generally speaking, such facts are of but limited value to the ordinary teacher.

Space does not permit a consideration of each of the conclusions given in the preceding chapter, but it will be noted that scarcely half of them have any direct bearing on, or significance to, educational problems in general. A positive correlation, for example, was found between *quick learning* and *amount retained,* but it will be noted that it is a very low one. This, as a scientific fact, however, is of value. It may also be valuable for the teacher to know that the popular impression that slow learners retain a relatively greater amount of what they have learned than do quick learners is, as a rule, erroneous.

To those who are connected with schools for feeble-minded and backward children it may be of value to know that here the correlation is slightly higher, especially in the case of prose and poetry. It would seem that with a class* of defectives those who learn exceedingly slowly are relatively poor retainers. It should be borne in mind, however, that the memory tests described are not satisfactory tests of reasoning, notwithstanding the fact that they are tests of a certain kind of mental ability.

The results of the experiments would seem to show that in general the power to remember meaningful material increases both with age and intellectual standing. This, however, is but what we would expect.

When we examine the various tables and notice the quantity or percentage of the material that has evidently been forgotten after the expiration of the time interval in question we

*i. e., a group or class in school, for example.

may associate this with an observation that doubtless all of us have at times made with reference to our early school work, viz., that a very considerable fraction of what we memorized in our early years has seemingly been totally forgotten. I say "seemingly" because we are apt to forget that what has here been forgotten has—as is proven by our "Method 2"—nevertheless left associations and impressions of value, even though these may not be readily recalled. We should remember that the mental work put on any problem, be it on a set of nonsense syllables, has nevertheless necessitated a certain amount of mental activity which may be of value in some way or other in the future. This is undoubtedly more true of the slow learner who (though, according to our tabulated results, may stand lower as to *amount retained*) may acquire a "something" that the quick learner does not.

The teacher should impress her pupils of the fact that what is learned and memorized in school is not meant to be useful for the school days alone, but for the pupil's entire life. The final value of whatever we learn is conditioned very largely by our ability to recall it later at pleasure. If we are unable so to do, then what we have learned is not really a "possession" in the sense of the word as we used it in Chapter II. Only time can show what real value anything once learned may have.

APPENDICES.

APPENDIX A.

Some of the Materials Used.

Digits.	Nonsense Syllables.	Words.	
			Poetry (100 *Words*).
5	VUS	TUB	And gentle Ellen welcomed her
0	YIF	PIN	With courteous looks and mild:
9	MAV	HEN	Thought she "what if her heart should melt,
4	JEP	BED	And all be reconciled!"
7	VOB	LID	
1	FEG	GEM	
5	WOF	BUD	The day was scarcely like a day—
2	TIB	CAR	The clouds were black outright:
6	NUZ	MAT	And many a night, with half a moon,
1	BOF	ROD	I've seen the church more light.
8	JED	JUG	
0	KIB	FOG	The wind was wild; against the glass
4	VEL	LAD	The rain did beat and bicker;
7	ZID	SOD	The church tower swinging overhead,
3	BOL	PEN	You scarce could hear the Vicar!
8	SEF	CAT	
1	YAB	RAG	And then and there the mother knelt,
6	KUV	BOX	And audibly she cried—
2	TEF	NET	Oh! may a clinging curse consume
9	NAD	GUN	This woman by my side.

Prose (100 *Words*).

(*From Kipling's "Kim."*)

The diamond-bright dawn woke men and cows and bullocks together. Kim sat up and yawned, shook himself, and thrilled with delight. This was seeing the world in real truth, this was life as he would have it—bustling and shouting, the buckling of belts, and beating of bullocks and creaking of wheels, lighting of fires and cooking of food, and new sights at every turn of the approving eye. The morning mist swept off in a whirl of silver; the parrots shot away to some distant river in shrieking green hosts: all the well wheels within earshot were at work.

Digits.	Nonsense Syllables.	Words.	
			Poetry (100 *Words*).
6	LEB	BIRD	To see a man tread over graves
1	DUT	RUG	I hold it no good mark;
5	NIV	EAR	'Tis wicked in the sun and moon,
8	POZ	SLATE	And bad luck in the dark.
2	DIB	CAP	
7	FEG	DOOR	
5	ZAD	BOX	You see this grave? The Lord he gives,
3	TOB	TREE	The Lord he takes away:
9	KED	CORN	O Sir! the child of my old age
4	BUP	AXE	Lies there as cold as clay.
7	KIF	SAIL	
2	RUZ	HINGE	Except that grave, you scarce see one
5		BUG	That was not dug by me!
9		SPOOL	I'd rather dance upon 'em
3		DOG	Than tread upon these three!
0		BOOK	
8		POST	Ay, Sexton! 'tis a touching tale!
1		GUN	You, Sir, are but a lad;
6		BEAN	This month I'm in my seventieth year,
2		LAMP	And still it makes me sad.

Prose (100 *Words*).

(*From Preface of Haeckel's "Riddle of the Universe."*)

The present study of the monistic philosophy is intended for thoughful readers of every condition who are united in an honest search for the truth. An intensification of this effort of man to attain a knowledge of the truth is one of the most salient features of the Nineteenth Century. This is easily explained, in the first place, by the immense progress of science, especially in its most important branch, the history of humanity; it is due in the second place to the open contradiction that has developed during the century between science and the traditional "Revelation."

Prose (160 *Words*).

(*From Kant's "Critique."*)

Time is nothing but the form of the internal sense, that is, of our intuition of ourselves. and of our internal states. Time cannot be a determination peculiar to external phenomena. It refers neither to their shape, nor to their position, etc., it only determines the relation of representations in our internal state. And exactly because this internal intuition supplies no shape, we try to make good this deficiency by means of analogies, and represent to ourselves the succession of time by a straight line progressing to infinity, in which the manifold constitutes a series of one dimension only; and we conclude from the properties of this line as to all the properties of time, with one exception, i. e., that the parts of the former are simultaneous, those of the latter successive. From this it becomes clear, also, that the representation of time is itself an intuition, because all its relations can be expressed by means of an external intuition.

Prose (100 *Words*).

(*From Franklin's "Autobiography."*)

But I soon found that I had undertaken a task of more difficulty than I had imagined. While my care was employed in guarding against one fault, I was often surprised by another; habit took the advantage of inattention; inclination was sometimes too strong for reason. I concluded, at length, that the mere speculative conviction that it was our interest to be completely virtuous was not sufficient to prevent our slipping, and that the contrary habits must be broken, and good ones acquired and established, before we can have any dependence on a steady, uniform rectitude of conduct.

Two Lists of Disconnected Sentences of 100 *Words Each.*

1. From the Kingdom of Heaven those angels have come.
2. This horse ate nothing but oats.
3. The wise man seizes every opportunity.
4. Ten years had elapsed and they therefore crowned him.
5. From my own experience I know he will never achieve success in that line.
6. The farce entitled "The Telltale Coo" was written by Haljass, an author who lived in Venebaft.
7. The wise man is one who realizes the value of industry.
8. The laboratories here are so arranged that the room for psychological work receives the most sunlight.
9. The work executed in prisons and reformatories is quitè frequently very well performed.
1. Opportunity comes both to the wise man and the fool.
2. The two walls met and the waters were dammed back.
3. We can say from Christ's teachings that God is Love.
4. I had dreamt that either rain or snow would fall.
5. Sin begets sorrow, as any knave can tell from experience.
6. The fairy thought that either son or daughter would suffice.
7. The school system is but one of our many failures.
8. A short time ago that nation was rich and prosperous.
9. From his writings we considered him a man who smoked.
10. "Waste not, want not," and "Grain in the morning sow."

As may be noted, the sentences are not only peculiar, but many of them are awkward. Many of them come from old Hindu fables, the awkward translation being desirable for the experiment in question.

APPENDIX B.

Typical Reproductions of Three Subjects Showing Method of Scoring for Digits, Nonsense Syllables, and Words.

(The Reproductions of the Prose and Poetry of the same three subjects are given on pages 115 to 117.)

Subject—ANNA F. (Senior, Albany Normal College).

Digits.

List studied	Reproduction (with Score attached)
5	5 . .
0	0 . .
9	9 . .
4	4 . .
7	7 . .
1	—
5	5 . .
2	1 .
6	8 . .
1	0 . .
8	4 . .
0	7 . .
4	3 . .
7	6 .
3	2 . .
8	9 . .
1	Total Score
6	for Digits: 28
2	
9	

Nonsense Syllables.

List studied	Reproduction (with Score attached)
VUS	VUS . . . .
YIF	YIF . . . .
MAV	MAV . . . .
JEP	JEB . . .
VOB	VOS . . .
FEG	WEF . . .
WOF	FEG . . .
TIB	TIB . . . .
NUZ	NUZ . . . .
BOF	LOD* . .
JED	GER* . .
KIB	KUL
VEL	YAB . . .
ZID	
BOL	
SEF	Total Score for
WAB	Nonsense Syllables: 39
KUV	
TEF	
NAD	

*LOD and GER both receive a score of 2, notwithstanding that they have only one letter correct, i. e., the vowel. As said on page 93, even though a syllable has two letters correct, but is not in the correct position (either relative or absolute), it receives no score at all. When, however, the absolute position is correct (as it is in the above case), each letter that is correct is scored. Therefore each of the above two syllables receives a score of 2,—1 because it is in the correct absolute position and 1 for having a correct letter.

Words.

List studied	Reproduction (with Score attached)
TUB	TUB . . .
PIN	PEN . . .
HEN	CAT . . .
BED	MAN
LID	PEN . .
GEM	RUG
BUD	MAT . .
CAR	RAG . .
MAT	WIT
ROD	RAT
JUG	BOY
FOG	RUN
LAD	
SOD	
PEN	
CAT	Total Score
RAG	for Words: 15
BOX	
NET	
GUN	

Subject—JENNIE Mc. (Senior, Albany Normal College).

Digits.

List studied	Reproduction (with Score attached)
5	5 . .
0	0 . .
9	9 . .
4	4 . .
7	7 . .
1	1 . .
5	5 . .
2	4
6	1 .
1	6 .
8	8 . .
0	0 . .
4	2
7	5
3	9
8	6
1	4
6	6 .
2	1 .
9	2 . .
	9 . .
	—
	Total Score
	for Digits: 26

Nonsense Syllables.

List studied	Reproduction (with Score attached)
VUS	VUS . . . .
YIF	VIF . . .
MAV	JEP . . .
JEP	RIL
VOB	BOV . .
FEG	SIR
WOF	WOL . . .
TIB	TID . . .
NUZ	
BOF	
JED	
KIB	
VEL	
ZID	Total Score for
BOL	Nonsense Syllables: 18
SEF	
WAB	
KUV	
TEF	
NAD	

Words.

List studied	Reproduction (with Score attached)
TUB	TUB . . .
PIN	PILL . .
HEN	RAG . .
BED	CAN
LID	....
GEM	....
BUD	....
CAR	BAR* . .
MAT	DOG
ROD	SUN
JUG	FLY
FOG	....
LAD	....
SOD	MAT . .
PEN	BAG
CAT	BOX . . .
RAG	TOP
BOX	LID . .
NET	MAN
GUN	Total Score for Words: 16

*BAR receives a score of two, although it is neither preceded by the correct word nor is it the correct word itself. The correct word here is CAR, and BAR receives a score of 2 as follows: 1 for having two letters correct and 1 because it is in the correct absolute position.

Subject—MAE K. (Senior, Albany Normal College).

Digits.

List studied	Reproduction (with Score attached)
5	5 . .
0	0 . .
9	9 . .
4	4 . .
7	7 . .
1	1 . .
5	5 . .
2	2 . .
6	6 . .
1	1 . .
8	8 . .
0	0 . .
4	7 .
7	—
3	3 . .
8	8 . .
1	1 . .
6	6 . .
2	2 . .
9	9 . .

Total Score for Digits: 37

Nonsense Syllables.

List studied	Reproduction (with Score attached)
VUS	VUS . . . .
YIF	YIF . . . .
MAV	TIB . . . .
JEP	BIF*
VOB	JEB . . .
FEG	....
WOF	....
TIB	....
NUZ	NAB . . .
BOF	——
JED	
KIB	
VEL	
ZID	
BOL	Total Score for
SEF	Nonsense Syllables: 17
YAB	
KUV	
TEF	
NAD	

*BIF can receive no score, it being in neither the correct relative position nor in the correct absolute position. It has, however, two letters that occur in BOF and for which it may have been mistaken. JEB (JED) therefore receives three counts, it being in the correct relative position with reference to the preceding syllable BIF (BOF). It will thus be seen that in cases like this what one syllable loses it gives to the other.

Words.

List studied	Reproduction (with Score attached)
TUB	TUB . . .
PIN	HEN . .
HEN	JUG . .
BED	RAT
LID	TAN
GEM	MUG
BUD	CAT . .
CAR	RUG . .
MAT	PEN . .
ROD	BED . . .
JUG	GUN . . .
FOG	——
LAD	
SOD	
PEN	
CAT	Total Score
RAG	for Words: 19
BOX	
NET	
GUN	

APPENDIX C.

The tables given below are practically the same as Tables Nos. 1 and 2 as given in the body of the work (pages 119 and 120), with the exception that the numbers under "Method 3" denote percentage of time lost (*i. e.*, amount forgotten) instead of percentage of time saved (*i. e.*, amount retained). Due to the addition of extra matter, the column numbers do not correspond.

TABLE I.

20 DIGITS. NORMAL COLLEGE SENIORS. GIRLS.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
			METHOD THREE.				METHOD ONE.				METHOD TWO.			
Subject.	Time of First Learning. Min.	Time After One Week. Min.	Absolute Time Saved.	Percentage of Time Lost or Amount Forgotten.			Rank.	Score (per cent.).			Rank.	Score (per cent.).		
El. W.	2.25	0.70	1.56	31			4	33			5	40		
Ed. W.	3.00	1.16	1.80	39			2	34			8	39		
H. B.	4.50	1.75	2.75	39	39.1		3	34	27.6		10	36	35.3	
F. Wi.	4.56	1.25	3.33	27			22	9			20	30		
M. K.	4.66	.50	4.16	11			1	37			6	40		
G. L.	5.00	4.33	.66	87		36.8	18	19		26.8	21	27		33.8
J. M.	6.00	2.33	3.66	39			6	30			13	34		
F. K.	6.00	3.00	3.00	50			9	27			16	32		
A. H.	6.16	2.80	3.33	41	34.6		14	24	26.		9	37	32.3	
R. W.	7.00	2.50	4.50	36			11	26			19	30		
C. C.	8.00	2.00	6.00	25			17	20			22	27		
H. M.	8.25	1.40	6.80	17			8	29			12	34		
H. N.	8.25	2.33	5.88	28			16	23			14	34		
M. T.	8.25	1.16	7.08	14			7	30			4	41		
F. Sc.	8.33	3.66	4.66	44	30.5		19	19	23.3		18	31	35.6	
F. St.	8.66	2.50	6.16	29			10	27			15	34		
B. O.	12.00	2.66	9.33	22			15	23			3	43		
S. T.	13.00	5.88	7.08	46		29.5	21	18		22.	17	31		35.5
A. T.	15.00	9.80	5.16	66			23	9			23	23		
E. S.	16.80	3.50	13.33	22			20	19			2	46		
L. J.	20.16	2.40	17.75	12	28.6		12	26	20.5		7	40	35.5	
F. R.	20.16	2.00	18.16	10			5	33			1	47		
E. T.	21.50	5.00	16.50	23			24	8			24	22		
J. Mc.	29.00	11.50	17.50	39			13	26			11	35		
Aver.	10.26	2.76	7.10	33				24				35		

TABLE II.

20 Nonsense Syllables. Normal College Seniors. Girls.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
			METHOD THREE.				METHOD ONE.				METHOD TWO.			
Subject.	Time of First Learning. Min.	Time After One Week. Min.	Absolute Time Saved.	Percentage of Time Lost or Amount Forgotten.			Rank.	Score (per cent.).			Rank.	Score (per cent.).		
M. K.	12.00	4.00	8.00	33			16	17			7	49		
El. W.	13.50	5.25	8.25	39			8	22			5	51		
Ed. W.	14.00	7.00	7.00	50	32.1		1	52	26.1		2	62	47.3	
F. St.	24.25	5.50	18.75	23			18	15			12	41		
A. T.	25.00	8.00	17.00	32			21	11			19	31		
H. B.	26.00	4.16	21.80	16			4	40			6	50		
A. H.	26.40	4.50	21.00	17		28.5	6	37		25.5	8	49		44.4
F. Wi.	28.00	2.33	25.66	8			2	48			1	65		
R. W.	28.00	7.00	21.00	25			13	18			15	38		
E. S.	29.56	15.00	14.56	50	25.		22	8	25.		23	17	41.6	
F. Sc.	31.00	10.25	20.75	33			11	29			10	43		
B. O.	31.75	5.50	26.25	17			12	19			16	38		
A. N.	32.00	9.16	22.80	28			9	21			9	45		
M. T.	33.50	13.40	20.08	39			23	7			24	18		
H. M.	34.00	8.80	25.16	26			14	18			13	40		
F. K.	34.00	6.40	27.06	17	32.5		10	21	18.8		20	30	3.33	
J. M.	35.50	15.66	19.80	44			17	17			17	37		
L. J.	36.08	15.00	21.08	41			7	29			21	29		
C. C.	37.00	16.50	20.50	45		31.8	19	12		20.6	18	36		36.4
E. R.	40.80	15.16	25.66	37			5	39			3	53		
S. T.	42.00	13.00	29.00	31			20	14	22.5		22	18	39.6	
J. Mc.	42.00	12.66	29.33	30	31.1		15	18			11	41		
G. L.	44.16	4.50	39.66	10			3	46			4	52		
E. T.	45.00	15.40	29.56	34			24	6			14	38		
Aver.	31.06	9.34	21.68					23				40		

APPENDIX D AND PLATES WILL BE FOUND IN POCKET.

INDEX OF NAMES

SUBJECT INDEX